Place and Public Transport:
Station Area Characteristics in Relation to Passenger Rail Ridership

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Declaration

I, Brian Garcia, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signature

Date

Abstract

This thesis uncovers the relationship between place and public transport, namely how station area variables from station design to neighbourhood demographics impact passenger rail ridership. Public transport is promoted worldwide to reduce environmental impacts of auto use and to increase public health through associated walking trips (Cervero et al., 2017, Chester and Horvath, 2010). However, little understanding of the pedestrian experience or aesthetic quality of passenger rail station areas exists because transport studies are typically a statistical analysis at a larger scale of inquiry (Bertolini, 1999). Meanwhile, plazas and streetscapes have been a focus of study in urban research for decades (Ewing et al., 2015; Whyte, 1980). To understand how the pedestrian's experience affects their mode choice more qualitative and experiential methods are necessary (Boarnet, Bostic, Williams, Santiago-Bartolomei and Rodnyansky, 2017; Boarnet, Giuliano, Hou and Shin, 2017). A mixed-method approach in this thesis, involving text analysis, an expanded statistical analysis incorporating place variables, and a place mapping site analysis provide an incorporation of qualitative data and pedestrian scale data into transport analysis. Berlin, Hong Kong, Medellin and London are examined through a streamlined statistical analysis. In Los Angeles, wealth indicators including household incomes, home value increases and home ownership had inverse relationships with passenger rail ridership. Meanwhile, population density and household density correlated with higher passenger rail ridership. Station design elements including the number of rail transfers available, underground line and underground station conditions along with paid parking at stations correlated with higher ridership. This thesis shows that qualitative and pedestrian level data collection may be incorporated into statistical analysis, while providing qualitative insights. From these results, transport planning agencies should place a priority on place analysis of potential station locations and invest in land use change and supportive urban design for public transport success.

Impact Statement

This thesis provides a mixed-methods approach to transport analysis, stressing the importance of human-scale inquiry in transport research. Place mapping and site analysis in this thesis satisfies calls for more rounded research in transport, providing an example of how qualitative data can be incorporated into statistical research. The place site analysis tool in this thesis updates early urban surveys with natural environment components and broadens municipal surveys by incorporating questions about urban design elements.

A statistical model developed from census data and site analysis for this thesis found that in Los Angeles, the number of lines at a station or transfer opportunities, household and population density, underground train routes, quality of the pedestrian environment, and low incomes correlated with passenger rail use. Higher incomes, end stations, number of cars available and owner-occupied housing correlated negatively with passenger rail use. Multivariate analysis found that the number of transfers available, low incomes, household and population density, and heavy rail underground routes had measurable impacts on passenger rail trips. This mixed-method strategy was expanded to case studies in Berlin, Hong Kong, London and Medellin. Place and system attributes largely matched the insights from the Los Angeles case with some exceptions, including central shopping areas of Hong Kong and Medellin that overcome other drivers of ridership.

Aspects of the built environment not included in United States census data are built environment design and social aspects including, shade, smooth sidewalks, feelings of safety, as well as station typologies, design and train propulsion types. This thesis provides an example for incorporating these indicators and elements into transport analysis. Very high ridership was found through site analysis to correlate with declines in the quality of the pedestrian environment as well as declines in the natural environment and social life. However, this research finds that substantial trip numbers are provided without sacrificing place quality.

These results show that passenger rail ridership can be encouraged through the design of the built environment or by placing stations in supportive neighbourhoods. Transport agencies with aims of urban quality, public health and higher trip numbers should provide a supportive and walkable urban design because they are integral to trip numbers and physical activity benefits.

I have presented this research at academic and professional conferences including for the Universities' Transport Study Group, the Association of American Geographers and the Urban Affairs Association. I have promoted this research while in visiting positions at Yale University, University of California Los Angeles, University of Hong Kong and to Los Angeles planning and transport agencies. Publications are in progress for academic and professional journals. I've taught these conclusions and research tools to undergraduate and graduate students.

The implications of this thesis include the importance of qualitative analysis in transport research while the policy implications support the understanding of place in transport planning as well as the important role of urban design in travel behaviour. This thesis is a foundation for examining the relationship between place and public transport.

Dedication

To Professor Sir Peter Geoffrey Hall.

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First and foremost, I thank my husband Justin without whom I couldn’t do much of anything. Secondly, I thank all my supervisors, Professor Stephen Marshall, Professor Sir Peter Hall and Dr. Robin Hickman, all of whom helped write this thesis. I also thank the army of generous academics and practitioners that indulged me in interviews, especially the California Center for Sustainable Communities at the University of California Los Angeles, the Environmental Compliance Department at the Los Angeles County Metropolitan Transportation Authority, the University of Hong Kong Department of Social Work and the Yale University School of Architecture for their guidance and hosting my research. I especially appreciate the hospitality of Professor Alan Plattus, Dr. Stephanie Pincetl, Dr. Mikhail Chester, Dr. Cris Liban and Dr. C.K. Law. Working with Professor Yvonne Rydin, Dr. Susan Moore, Professor Sir Peter Hall, Dr Nikos Karadimitriou, Professor Stephen Marshall, Dr. Camilo Boano and the Development Planning Unit, supporting their research or teaching alongside them has been an invaluable experience in my life.

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“The details are not the details. They make the design.”

Charles Eames

“It is difficult to design a space that will not attract people. What is remarkable is how often this has been accomplished.”

William H. Whyte

"Nothing is more fatally easy, in the study of social and economic processes, than the fallacy of extrapolation."

Peter Hall

"All models are wrong but some are useful."

George Box

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1 Introduction

This thesis examines the effect that place[1] has on public transport[2]. This thesis focuses on the effect of station place context on passenger rail ridership[3]. A mixed-method approach provides insights into higher ridership and the greater associated benefits of more sustainable[4] travel, including better environmental quality and public health (Badland et al., 2016; Boarnet et al., 2016; Cass and Faulconbridge, 2016; Chester and Horvath, 2009; Mueller et al., 2017; Nieuwenhuijsen, 2016; Nieuwenhuijsen et al., 2017). Los Angeles is the main case study due to the rapid growth of the passenger rail system and the rate of urban change. Analysis of Los Angeles provides guidance for other cities attempting major travel and land use change. Berlin, Hong Kong, Medellin and London, are introduced for a comparative analysis on the study of station design and place context. These cities provide a diverse cohort but also have similarities for comparison. These five case studies consist of an historical and geographic background analysis, a statistical analysis typical to transport studies and a site analysis of station design and place context (Frank et al., 2015; Ksiqzkiewicz, 2012). This analysis shows were new passenger rail stations should be located and what place attributes, urban design or land use development, should be incorporated with them for greater success and benefit.

[1] Place is composed of physical or aesthetic qualities of a space as well as buildings, behavioural settings and the ephemeral qualities of people and activities (Carmona, 2010). In this thesis the place investigated is the context, or setting of the passenger rail station area and adjoining neighbourhood characteristics, including rail station architecture, density of the area, the physical attributes of the station, and demographics including wealth of the residents that live nearby the passenger rail station. Place and context are synonyms and interchangeable in this thesis.
[2] Public transport includes buses, trains and other forms of travel available to the public typically through ticket sales and typically on fixed routes (Stevenson and Lindberg, 2010). However, public can have meaning on a scale. Public transport in the analysis of this thesis refers to passenger rail lines and passenger rail station areas.
[3] Passenger rail ridership trip numbers are based on entries and exits through turn styles or boarding gates at passenger rail stations to analyse the place aspects of station areas. These numbers have been acquired from the transport agencies of each city case. Entries and exits at stations were managed into the annual trip number format.
[4] Sustainability is the principle that equity, environmentalism and biodiversity should guide decision-making and policy (Basiago, 1995). Proponents of sustainability promote practices that prevent irreversible damage to the environment (Basiago, 1995). Ecological preservation crosses the borders of agriculture, energy, industry, social equity, financial responsibility and transport (Basiago, 1995).

The rapid increase in urban populations and the increasingly polycentric nature of cities are major challenges of our time (Bakogiannis, 2014; Beauregard, 2008). Transport is estimated at 14% of global greenhouse gas emissions (Pasha et al., 2016). Public transport use in cities has been connected to better public health due to greater associated walking trips when using public transport and lower pollution due to reduced car use (Ganning et al., 2016; Saelens et al., 2014). Mode shift from driving to more sustainable travel methods such as walking and passenger rail has been named the key to capturing environmental benefits from passenger rail (Chester and Horvath, 2010; Chester and Horvath, 2009; Ewing and Hamidi, 2014; Guerra and Cervero, 2011).

The experiences of the pedestrian are a critical linchpin in passenger rail ridership, mode shift and subsequent environmental benefits. These challenges and complexity require a mixed-method approach to research and understanding (Wang et al., 2015). Site analysis included in this thesis responds to insufficiencies in typical statistical transport research to understand urban quality and pedestrian experience (Cao et al., 2009; Ganning et al., 2016). A place strategy that includes urban design and local context increases passenger rail use and transport mode share.

This thesis is structured in twelve chapters, with **Chapter 2**, the Literature Review following this chapter. **Chapter 3**, the Research Strategy and Methods follows the Literature Review. **Chapter 4** presents the Los Angeles case study background, including geographical information, the studied passenger rail system and funding or policy context of the expanding rail system. **Chapter 5** contains the regression analysis for the Los Angeles case. **Chapter 6** presents a site analysis method, with the place survey, for identifying patterns in Los Angeles passenger rail ridership. The cases of Berlin, Hong Kong, London and Medellin follow in their own respective chapters, the Berlin case in **Chapter 7**, the Hong Kong case in **Chapter 8**, the London case in **Chapter 9** and the Medellin case in **Chapter 10**. **Chapter 11** is a comparative chapter that synthesizes the previous five case studies in relation to each other. **Chapter 12** is the concluding chapter.

2 Literature Review

This literature review presents key aspects in the investigation of the relationship between place and passenger rail ridership. This research is organized around three major components, physical place along with design, people and their behaviour in place, and finally a discussion on the typologies and the operationalisation of design policy. Transport use and its relationship to place has multiple and multi-directional influences (Hickman et al., 2017). Issues concerning transport that have been identified as deserving attention are both factors of place and the people that use them, including neighbourhood characteristics such as density, access and income (Naess et al., 2017).

Associations between urban green space, sustainable modes of travel and human health have been found to have overlapping relationships (Townshend and Lake, 2009; Tzoulas, 2007). Different urban forms have different costs such as land consumption as well as mobility generation (Camagni et al., 2002). Wasteful characteristics of sprawl, or low-density spread development include poor land use efficiency (Camagni et al., 2002). Urban design has the potential to enhance the health and well-being of people affecting health determinants by providing access to public transport, active mobility, green space and local amenities (Giles-Corti et al., 2013; Townshend, 2017; Townshend and Lake, 2016). Attractiveness of neighbourhoods has been shown to increase residential walking (Giles-Corti et al., 2013).

A large body of literature states that living in more walkable neighbourhoods is associated with increased walking and beneficial health outcomes (Badland et al., 2017; Frank et al., 2015). Obesity is a significant problem in many countries contributing to poor health and social outcomes (Townshend, 2017; Townshend and Lake 2009; Townshend and Lake, 2016). Ebenezer Howard popularized the healthy garden city, yet convincing models of sustainable urban forms have been elusive in development (Jabareen, 2007; Townshend and Lake, 2016). Today, studies have revealed that 20% of mortality could be prevented if exposure to air pollution, noise and heat were limited and access to green space were increased due to physical activity (Mueller et al., 2017). The greatest reductions in mortality are connected to increased physical activity, such as walking, and reductions in exposure to air pollution, traffic noise and heat (Mueller et al., 2017). Increased physical activity could extend life expectancy and save billions (Mueller et al., 2017). People in deprived areas live shorter lives than those in less deprived contexts (Townshend, 2017). Furthermore, the auto traffic environments of dense urban areas are safer than the lower auto volume environments of suburbs due to lower auto speeds in the cities (Ewing and Dumbaugh, 2009).

Public transport users have been found to have more physical activity and daily walking time overall (Saelens et al., 2014). In the past decade research has grown and the evidence is clear that the built environment can contribute or hinder to health, however real progress has been slow (Townshend and Lake, 2017). Walkable neighbourhoods and the urban design of cities in general are not always delivered or priorities in the planning process (Badland et al., 2017). Land use adaptation strategies are secondary to passenger rail projects purpose as movers of commuters (Duffhues and Bertolini, 2016). The built environment including, urban design forms, settlement density and housing could have major impacts on reducing greenhouse gasses, motor vehicle dependency and even travel demands in general (Dulal et al., 2011). Urban planning and design can have large impacts on these challenges in the long term, through shifts to alternative travel modes such as walking, cycling and passenger rail (Dulal et al., 2011). A mixture of high density residential and employment centres could also influence shorter commute journeys reducing the private vehicle use, if accompanied by the appropriate public transport (Dulal et al., 2011). However, existing road networks are most often based on reducing travel times for autos and rarely consider the environment, including vehicle emissions (Sharma and Mathew, 2011). Factors of place, including residential density and land use mix are strong predictors of activity such as travel behaviour (Leck, 2006). The evidence is clear that transport planning is multifactorial, impacting human health and that urban environments and transport planning must be considered more holistically (Townshend, 2017).

2.1 Physical Place

Urban design and the station area physical environments facilitate the use of passenger rail for subsequent beneficial outcomes. Public transport is dependent on urban form and also influences that form (Camagni et al., 2002). Urban design as a process of making physical urban environments is inherently multi-disciplinary and as physical objects, places where people, ideas and energy come together (Carmona, 2016).

Cities and their patterns have been classified by their physical or fixed attributes in Kevin Lynch's Image of the City, where he organized urban elements into paths, edges, nodes districts and landmarks (Lynch, 1960). More recently, urban processes or flows and time have been introduced to the study of how cities function and the urban design discipline (Carmona, 2010, 2016).

New Urbanism has been one the more popular design guidance or prescription movements to promote urban design and architecture for their power to facilitate or affect human behaviour for beneficial outcomes (Boarnet and Crane, 2001). This movement emerges from the concept that behaviour follows form rather than form following function (Boarnet and Crane, 2001). Jane Jacobs' and more recent champions like Jan Gehl and Project for Public Spaces have promoted behaviour spawning forms and cities (Carmona et al., 2010; Jacobs, 1961). These agendas involve creating a sense of community through form, movement and scale largely through mixed land uses and getting people out of their cars (Boarnet and Crane, 2001). They view pubic space as a necessary part of the physical and social fabric of cities and wish to impact public spaces with a social vibrancy through friendly or familiar forms (Boarnet and Crane, 2001). Transportation choices are likewise affected by urban or environmental design (Ganning et al., 2016). They argue that while physical solutions alone will not solve urban ills, neither will economic or community solutions solve urban ills without a combined physical approach (Carmona et al., 2010).

2.1.1 Polycentric Cities

At the largest scale of urban design, is the urban form or organization of the city and the context that people and public transport must navigate. Reid Ewing describes the evolution of cities towards a polycentric condition, claiming that at least in the United States "Monocentric development is an anachronism, as downtowns have become just one of many centres in large metropolitan areas." (Ewing, 1997, p. 107-108). All cities are some mixture of polycentric form, centralization, and sprawl (D. Hall, 2010; P. Hall, 1966, 1989, 1998; P. Hall and Pain, 2006). Bertolini argues that both centralisation and decentralisation are at work in cities (Bertolini, 1999). More insight and new methods to study these complex dynamics of station area development are needed (Bertolini, 1999; Peek et al., 2006). Meanwhile, compactness and centralisation are not necessarily the same and both have their own implications for the environment and infrastructure use (Jenks et al., 1996).

However, these patterns are challenging for passenger rail networks to connect successfully. In United States polycentric metropolitan areas such as Los Angeles, employment subcentres compete with the traditional city centre (Boarnet, Hong and Santiago-Bartolomei, 2017). Multi-nodal conditions have implications for public transport because employment centres drive a large portion of passenger numbers, yet polycentric cities have many sub-centres that possibly even compete with one another. One study found that access to jobs near employment sub-centres had a larger impact on vehicle miles travelled than access to jobs within the centre because of the increased walkability of traditional centres (Boarnet, Hong and Santiago-Bartolomei, 2017).

Change of transport infrastructure is very slow to occur, housing or business locations are quicker to change, while employment or firm locations are more adaptable and can change location rapidly, and people able to adjust their travel patterns most easily (Lynch, 1972; Wegener and Furst, 2004). These macro scale issues and these tensions between nodes and dispersion is the context for public transport implementation in Los Angeles, and other cities, and have challenged public transport implementation and use.

There are some opportunities for polycentric cities though. Investment in walkability combined with public transport in the periphery, or in polycentric conditions, are ways to make reductions or offsets in vehicle miles travelled (Boarnet et al., 2016). The largest reduction in car use is possible in the suburban and rural communities because of their extensive car use (Dieleman et al., 2002). This is especially true because jobs within five miles have a larger effect on vehicle miles travelled than those jobs outside the five-mile distance (Boarnet et al., 2016). Within a statistical model, moving a representative area unit from the suburbs to a city centre condition can reduce vehicle miles travelled by 46.6 % (Boarnet et al., 2016). Agglomeration and opportunities for walking are keys to public transport benefits such as increased public health and reduced adverse environmental outcomes.

2.1.2 Urban Form and Sustainability

Today, many countries have policies to reduce auto use and favour the use of public transport, cycling and walking (Dieleman et al., 2002; Krizek, 2003). Compact urban forms and pedestrian friendly communities are seen as especially effective for reducing auto dependency (Dieleman et al., 2002). Mode shift from driving to more sustainable travel methods such as walking or passenger rail has been named the key to capturing environmental benefits from passenger rail (Chester and Horvath, 2010; Chester and Horvath, 2009; Ewing and Hamidi, 2014; Guerra and Cervero, 2011; Mees, 2010).

Analysis of sustainable urban forms includes categories including, compactness, sustainable transport, density, mixed land uses, diversity, passive energy designs and greening (Jabareen, 2007). Types of sustainable urban form concepts also occur including, neo-traditional development, the compact city, the eco city and urban containment (Jabareen, 2007).

Despite decades of criticism, sprawl and urban dispersion has continued to occur nearly everywhere in the world (Hall, 1966; Lynch, 1961). Funnelling sprawl along transport lines and nodes may be one way to manage growth (Hall, 1966). However, even sprawl is more complex than its criticisms with commuter rail lines sometimes facilitating sprawl (Ganning et al., 2016). Many people want a certain amount of open space and low-density development including trees and a connection to the natural environment (Garcia and Riera, 2003). The garden city movement and land use zoning were responses to urban ills of dense cities (Fishman, 1998; Sharifi, 2016). Furthermore, cities continue to be intense sources of consumption of energy and objects (Brahinsky et al., 2014; Sasser 2014). Consumption in the United States and Europe far exceeds the consumption of much larger populations in the developing economic world (Brahinsky et al., 2014; Sasser 2014).

The compact city concept has evolved to include an arrangement of compact centres along public transport routes (Jenks et al., 1996). The underlying premise is that high density living will reduce environmental impacts, most logically through travel energy outcomes (Jenks et al. 1996). However, the compact city is most often tied to the intensification and rehabilitation of historic European cities (Jenks et al. 1996). Meanwhile, many of these cities are intense to the point of capacity and significantly tourist areas (Jenks et al. 1996). There is a quality of life threshold on the side of compactness and intensity as well, while at the same time other models of cities may be beautiful, healthy, walkable and sustainable (Harris, 2008; Jenks et al., 1996; Robinson, 2006; Robinson, 2011). The idea of urban containment, concentrated development and reducing the needs to travel is still valuable yet the compact city concept needs advances in research and practice to understand the more complex reality of cities and consumption (Jenks et al., 1996).

These different urban forms contribute to sustainability differently and must be managed carefully with different urban forms having different costs and benefits (Jabareen, 2007). Also, different sustainable urban forms may be the result of different sustainable objectives (Jabareen, 2007). Urban design has been found to have an effect on transport and on greenhouse gasses and should be considered in new community planning (Pasha et al., 2016). Increases in commercial areas, highways and train stations also were found to encourage transit use (Pasha et al., 2016). It may be possible for typologies to be designed and operationalised for certain outcomes, in station planning and architecture (Reusser et al., 2008).

Some commonalities for more sustainable urban forms include places that have higher density, diversity, compactness along with mixed land uses, a network based on sustainable transportation, greenery or greening and passive energy sources (Jabareen, 2007).

By fine tuning concepts in a data informed way and context specific way, sustainable urban form concepts like the compact city will move beyond a romantic notion and become useful for urban design practice (Jenks et al., 1996; Robinson, 2006; Robinson, 2011). Advances in sustainable urban form concepts are needed with urgency to not only understand the role the built environment plays in human behaviour and reduced auto use but to operationalise cities as solutions to these environmental challenges.

2.1.3 Place and Activity

In California, neighbourhood characteristics have a separate influence on travel demand than self-selection[5] of areas with public transport (Cao et al., 2009). Self-selection is the theory that people that would like to take public transport move to those areas (Cao et al., 2009). However, this presumes people have a freedom to

[5] Self-selection refers to residents that prefer certain forms of travel, for example walking, that move to neighbourhoods amenable for walking (Cao et al., 2009). Associations between self-selection and travel behaviour are undefined yet this proposed phenomenon is deeply associated with the built environment's design and organization for modes of travel (Cao et al., 2009).

move, economic, physically and socially (Cao et al., 2009). The relationship between travel behaviour and the built environment is very complex with evidence pointing to self-selection and the built environment as compounding forces effecting travel behaviour rather than separate forces (Ganning et al., 2016). Yet, even after controlling for self-selection there have been confirmed relationships between the built environment and travel behaviour (Ganning et al., 2016).

Neighbourhood characteristics are associated with travel decisions, especially non-motorized travel frequencies such as walking and biking (Cao et al., 2009). Neighbourhoods with public transport are perceived to have greater accessibility and more socializing as well as attractiveness (Handy et al., 2005). A land use strategy that puts people in close proximity to their destinations and provides them with multiple ways of travel, including easy walking, can reduce driving and the subsequent environmental costs of auto emissions (Handy et al., 2005). An increase of land use amenities creates a ridership increase up until a tipping point (Hu et al., 2016). Cities with comprehensive public transport facilities and supporting public policies, such as urban intensification, have even lower vehicle miles travelled numbers that is not completely explained by mode shift alone (Ewing and Hamidi, 2014). Despite the need for more research, the urban form has a clear relationship with travel and sustainability.

Streetscapes have been found to be significant predictors of physical activity (Frank et al., 2016). Combinations of densities, land use mixtures, aesthetics, safety and street connectivity all translated in some cases to physical activity (Frank et al., 2016). Of twenty streetscape variables investigated, the proportion of windows on the street, the proportion of active street frontage and the number of street furniture was shown to positively correlate with foot traffic volumes in New York City (Ewing et al., 2015). Places with land use mixtures tend to be places where people walk for leisure and transport (Frank et al., 2016).

Research of the built environment has been operationalized with D variables of density, diversity and design in over 200 studies (Ewing et al., 2016). Design, however, is the more nuanced D and requires more attention (Ewing et al., 2016). Pedestrian environments and travel have at least as much to do with street elements as they do macro scale qualities that have commonly been studied statistically such as average block size (Ewing et al., 2016). A broad study of literature reviews on the built environment's impact on pedestrian travel found 30 literature reviews that related walking to design. Only six studies were found to narrow down beyond street network or road routes, to include the elements of the street and the streetscape design (Ewing et al., 2016). There has been some connection found between aesthetically pleasing neighbourhoods, pedestrian elements and infrastructure such as sidewalks and traffic signals with physical activity (Ewing et al., 2016). Specific architectural style elements have had less associations connected to physical activity than urban design elements (Boarnet et al., 2011; Ewing et al., 2016).

A combination of the historical urban observation of Whyte, Jacobs and Gehl now can be combined with statistics to provide guidance for projects that aim to create pedestrian friendly environments and well trafficked environments (Ewing et al., 2015). Streetscape elements such as trees, benches and sidewalk attributes can be input against traffic amounts, or use, to find relationships through statistical analysis (Ewing et al., 2015).

2.1.4 Density

Density has been identified as integral to public transport ridership in many cases (Mees, 2010). Minimum densities are thought to be fundamental to high ridership numbers in public transport. Ridership numbers often justify mass transport expenses, through fare recovery, however in a polycentric urban condition with multiple business centres ridership numbers are dispersed. As cities grow in a multi-centre fashion, transit riders often make cross trips from satellite node to satellite node without moving through the city centre. The London Overground is interesting because it allows for fringe to fringe transit and to a similar extent the Berlin S-Bahn but, the S-Bahn does a better job of connecting to various parts of the Berlin city centre. The cities with the largest ridership numbers tend to have the most centralized and largest central business districts, like Manhattan. This has been the trend in quantifying public transport use but is limited because it doesn't consider the many other types of trips, including leisure trips or combined trips through walking. While it is clear that density plays an important role in transport planning and ridership success, it can disguise a complex relationship between urban form and transport benefits.

A qualitative and quantitative study involving density and distances in travel found that results varied by place and strength of city centres with job density and population density having impacts in one city but not the other (Naess et al., 2017). Mode shares often correlate with economic activity rather than density (Mees, 2010). Central business districts or nodes of employment often drive public transport ridership (P. Hall, 1966). In some cases, density has played no significant part in walking trips while commercial or services in a zone increased walking trips (Transportation Research Board, 2004). However, vacant land reduced walking trips yet (Transportation Research Board, 2004). Light rail ridership has been identified as higher in low income, high-density areas (Pijawka and Gromulat, 2012)

Evidence from Santiago de Chile shows that the urban form of a zone has an influence on travel behaviour, while concentrations of commercial or services uses attracted people (Zegras, 2004). The premise that density, diversity and design reduced the number of motorized trips, increased the share of non-motorized trips and reduced the distances of motorized trips is common throughout this field of research (Zegras, 2004). In Chile, it was found that a higher share of commercial or service uses in a zone increase walking trips and vacant land decreased them according to traditional theory but, in contrast to a presumption in transport studies, density played no significant part (Zegras, 2004).

In a detailed study of density, it was found that higher densities will provide higher ridership and a larger return on fares yet there is no consensus on density numbers or amounts of returns a specific density will provide (Guerra and Cervero, 2010). Meanwhile, destinations remain an equal and most likely more of a determinant in ridership (Guerra, 2010). When household size, income and number of cars were added to their analysis of vehicle trips and mode choices in the San Francisco Bay Area, design and density lost much of their predictive power but were still significant (Cervero and Kockelman, 1997). Advocates of densification promote discouraging the car to thereby promote a modal shift, for greater environmental benefits (Melia et al., 2011).

In the 1960s Mel Webber wrote about dispersed life or community without propinquity and Kevin Lynch described the setting for a polycentric web of development in (Lynch, 1961; Webber, 1963). In the middle twentieth century there was optimism about the opportunities of suburban development and a reaction to the crumbling city centres. However, now we can see congestion in the outer suburbs and hear dire warnings of emissions caused Climate Change. In a more recent study, a negative relationship exists between density and vehicle use across the several countries they surveyed (Melia et al., 2011). Normally, pro density policies should reduce vehicle use but, extreme concentration in these areas could cause a range of local environmental and social problems (Melia et al., 2011). Therefore, we will need policies to manage this increased localized congestion due to intensification (Melia et al., 2011).

Effective systems in Germany and Switzerland rely on timing and frequency to produce high ridership numbers rather than density (Mees, 2010). However, evidence shows that while density and ridership have a complicated mathematical relationship there is strong relationship (Guerra and Cervero, 2011; Guerra and Cervero, 2010). For example, density numbers and probability of ridership do not have direct relationships with “An area of 10,000 commuters with an average 30% probability of taking trains will generate twice as much riders as an area of 3,000 with a 50% probability” (Guerra and Cervero, 2011, p. 5). Density is an important component of transport that we still have much to learn about.

2.1.5 Transit-Oriented Development

Transit-oriented development has been a promising means of physically reorganizing cities and can be a policy context as well as a typology of building and organising cities. Transit-oriented development is a strategy of combining or concentrating building development with public transport predominantly passenger rail lines (Cervero et al., 2002; Cervero and Kockelman, 1997). Transit-oriented development is also called joint development, due to public private partnerships between transport agencies and private land developers necessary to see projects completed. Transit-oriented development is a subset or specific type of urban design strategy for environmental or social benefit (Cervero et al., 2002; Cervero and Kockelman, 1997). Transit-oriented development can be thought of as a type of living, involving certain types of buildings and urban organization around a specific type of travel, for the purposes of this thesis, passenger rail (Ganning et al., 2016). So far, few studies have empirically identified transit-oriented development outcomes or operations (Kamruzzaman et al., 2014).

Recent demographic changes in the United States have coincided with an increased interest in public transportation and living in more intense areas, including childless couples, the changing roles and mobility of men and women, immigrant influxes, empty nesters and steadily worsening traffic congestion (Cervero et al., 2002). The United States Federal Government launched pilot programs in ten United States cities in 1998 and more have followed (Cervero et al., 2002). This has been called a transit-oriented development renaissance and has been fuelled by housing shortages, congestion and smart growth agendas (Cervero et al., 2002).

Transit-oriented development offers some hope for mitigating traffic, or allowing for traffic growth better, reducing potential air pollution and energy depletion while stemming some of the social disintegration of cities and neighbourhoods (Cervero et al., 2002). There are two problems, one of reducing current environmental and population challenges, and the second of planning to accommodate for new growth of population and travel. Voters, in California in particular, seem to be expressing concerns for quality of life, reduced traffic and reducing some of negative environmental, economic and social by-products of sprawl (Cervero et al., 2002). Transit-oriented developments manifest a desire for widening travel choice, for urban regeneration, for face to face contact and for more diversity (Duany, Plater-Zyberk, and Speck, 2010).

Context plays an integral part in the efficacy of public transport investment benefits. Transport investment can be difficult to justify solely on economics because there are different impacts at different levels (Banister and Thurstain-Goodwin, 2011). In a study of Salt Lake City, it was found that commuter rail suppressed development in neighbouring non-commuter rail tracts (Ganning et al., 2015). It was also found that the built environment was more likely to influence the use of commuter rail than residential self-selection, the idea that residents that would like to use public transport move into places with public transport (Ganning et al., 2015). Land use change is also associated with commuter rail transitioning those areas from single family residential uses to increases in multifamily and mixed uses (Ganning et al., 2015). The spatial effects of commuter rail on a neighbourhood vary by context yet provide for many potential benefits from mixed-use, denser living and passenger rail use instead of auto use (Ganning et al., 2015).

Many of the benefits of increased public transport are the result of accessibility and agglomeration (Banister and Thurstain-Goodwin, 2011). These include, better access to public goods and increased proximity of firms and supporting businesses to each other. In fact, a large number of the benefits of public transport are not internalized within the transport system. Indirect benefits and costs, whether they be environmental, social, or economic, remain difficult to quantify discretely (Banister and Thurstain-Goodwin, 2011).

Proximity of light rail has been found to increase nearby property values and that these may increase in value with increased proximity to rail (Hess and Almeida, 2007). A rail plus property development strategy has been successful in Hong Kong, with more than half of all income to operators being from residential development (Cervero and Murakami, 2009). This combined development strategy has focused on pedestrian experience, commercial offerings and housing creation has increased ridership and housing value at the same time (Cervero and Murakami, 2009). Land that is more accessible to rail stations show evidence that office rents rose as nearby ridership rose (Cervero, 1994). Furthermore, in a comparative study, office vacancies were lower, average building densities were higher, and regional growth was larger (Cervero, 1994). When market conditions are favourable, rail creates positive impacts on station area office markets (Cervero, 1994). A combined approach of rail investment with real estate investment magnifies these effects (Cervero, 1994).

Availability of light rail in Los Angeles has had significant effects on travel behaviour, including a reduction of vehicle miles travelled by approximately ten miles per day, for those that live within ¼ mile of light rail (Boarnet et al., 2013). New residents of these areas showed an even further reduction of vehicle miles travelled (Boarnet et al., 2013). In Portland, a similar but lesser effect was noticed with transit reducing vehicle miles travelled by three miles (Ewing and Hamidi, 2014). Cities with comprehensive public transport facilities combined with supporting public policies, such as housing intensification near stations have even lower vehicle miles travelled (Ewing and Hamidi, 2014). These reductions are not completely explained by mode shift alone (Ewing and Hamidi, 2014).

Terms such as sprawl, compact and transit-oriented development are most usefully defined as a scale or adjective range rather than a static noun (Ewing, 1997; Gordon and Richardson, 1999). Transit-oriented development and transit joint development have a range of scales and characteristics but have some common traits, including compactness, pedestrian and cycle friendly environments, with public spaces near stations, and stations as a community node, organized around a passenger rail station (Cervero et al., 2002).

Transit-oriented developments are often multiple city blocks in size with neighbourhood and neighbourhood altering characteristics (Cervero et al., 2002). These are usually coordinated by a public agency, as they are in Los Angeles (Cervero et al., 2002). They often involve intensifying commercial developments, with mixed land uses and introducing public amenities (Cervero et al., 2002). Improved quality of life and landscape are also common to transit oriented development efforts (Cervero et al., 2002). Developing and intensifying land near a transit station, with diverse uses, is also common to transit oriented developments (Boarnet and Crane, 1997; Boarnet and Sarmiento, 1998). However, definitions of transit-oriented development are sometimes an ideal wish list of what a project might do rather than a useful definition to understand how they operate. An appropriate, albeit general, definition used in this thesis for a transit-oriented development is as follows:

1. A mass transit led development strategy that prioritizes congregation, mixed land uses and the pedestrian realm around transit portals through direct investment, catalytic attraction, or policy intervention.

Transit-oriented developments are also not limited to train systems and many bus transit systems have been successful such as in Curitiba, Brazil (Cervero et al., 2002). The cases presented in this thesis focus on fixed rail transit-oriented developments because of the greater opportunity for spatial benefits and the more common accompaniment of transit joint developments (Cervero, 2002; Cervero and Duncan, 2002).

Transit joint developments are usually project specific and based on a single city block, if varied or large, in size (Cervero et al., 2002). These development projects are often the result of a public private partnership, which is how they work in Los Angeles (Cervero et al., 2002). Generally, it is difficult to bring these large development projects to fruition financially, however, many cities have been successful in producing built outcomes (Cervero et al., 2002). Transit joint developments have two common components, beyond being a real estate development integrated with mass transit. These are a revenue sharing agreement and cost sharing arrangements between the public agency and the private developer (Cervero et al., 2002). The components of transit joint developments can be broken down to two fundamental attributes:

1. A real estate development near or integrated with mass transit.
2. Involving a public private partnership.

Transit joint development may be folded into the umbrella term transit-oriented development, except when discussing particular operational or financial components of a joint development projects.

Transit-oriented development (TOD) is often proposed to promote leapfrog intensity with more usage, density and development at public transport stations (Ewing, 1997; Gordon and Richardson, 1999). Transit oriented development is a strategy of concentrating development near or above passenger rail station portals. In a transit-oriented development strategy many of these stations are accompanied with a concentration of density, uses and people.

Certain considerations have become common in these types of semi-public or partially public projects such as security, economic and community development, considering the cultural and contextual history, building social capital, and strengthening the relationship between the neighbourhood and transit system (Cervero et al., 2002).

Major gaps can be discerned from the previous literature on transit-oriented development (Cervero et al., 2002). The complexities of how transit joint developments work are not understood (Cervero et al., 2002). How transit-oriented developments have actually reduced environmental impacts or increased walking has not been sufficiently defined (Cervero et al., 2002). Goals of sustainability have been backed more by faith than research (Cervero et al., 2002). Transit-oriented developments are about more than enhancing ridership and improving traffic; they exist within a complex urban network and have wider social and environmental goals that make them hard to understand, unravel or quantify their benefits.

In a recent study of the newest light rail line in Los Angeles, the Exposition Line, Boarnet et al. researched the before and after impacts of the new light rail service on vehicle miles travelled (Boarnet et al., 2013). They concluded that the Exposition line had significant effects on travel behaviour, including a reduction of vehicle miles travelled of approximately 10 miles per day for those who lived within a ¼ mile radius (Boarnet et al., 2013).

A large portion of the new passenger rail lines in Los Angeles, including the Exposition Line, have been through lower income neighbourhoods. Residents of low-income neighbourhoods often have much more connections to jobs by car than transit yet there are strong associations between low incomes and passenger rail use (Boarnet and Giuliano, et al., 2017).

After the introduction of the Exposition line in Los Angeles carbon emissions were reduced by 27.17% for households within ½ mile of new stations versus households beyond the ½ mile distance (Spears et al., 2017). Rail travelled trips near light rail in Los Angeles tripled for households within walking distance (Spears et al., 2017). The introduction of light rail in Los Angeles has increased the walking and physical activity for people living within ½ mile (Hong et al., 2016). The results were more substantial for those people that were more sedentary suggesting that soft policy approaches such as walkability in the design process could be even more effective at capitalising on the relationship between walking and nearby public transport (Hong et al., 2016).

More and more evidence points to the effects of passenger rail in Los Angeles reducing vehicle miles travelled, subsequently reducing carbon emissions and increasing walking to and from stations. When associated with land use change, passenger rail interventions offer a real opportunity to meet climate change mitigation goals as well as public health benefits (Spears et al., 2017).

Ewing and Hamidi looked at the direct and indirect effects of light rail on vehicle miles travelled (VMT) in Portland, Oregon and found a reduction of three vehicle miles for each area they surveyed (Ewing and Hamidi, 2014). They also found that reducing VMT and greenhouse gases depends on mode shift away from auto use, yet they note that previous research has shown modest reductions in mode shift (Ewing and Hamidi, 2014). Cities with comprehensive public transport facilities and supporting public policies have even lower VMT that is not completely explained by mode shift alone (Ewing and Hamidi, 2014).

The long-term influences of public transport show that mixed-use land uses near to stations have a substantial higher rate of walking and biking trips (Ewing and Hamidi, 2014). This reduces auto travel by more than distance of trip (Ewing and Hamidi, 2014). Trips can be consolidated in land use conditions that are mixed-use and compact or safe for pedestrians. For example, even if those that live near public transport do not use public transport, they will drive less because of compact living and walking or biking trips, instead of driving, to the local store (Ewing and Hamidi, 2014).

Mixed-use neighbourhoods offer multiple opportunities. Supportive zoning policies can maximize vehicle miles travelled and greenhouse gas reduction while offering close proximity to key destinations, overlap of journeys as well as economic uplift and social benefits (Ewing and Hamidi, 2014).

2.1.6 The Park and Ride Station Paradox

It is a difficult balancing act to fit transit-oriented development and new public transport into auto centric urban forms. One strategy is to provide parking at suburban stations, commonly called park and ride stations. Research of the San

Francisco Bay Area Rapid Transit (BART) system in the United States has suggested that rail stations alone are insufficient to channel land use development (Webber, 1976; Cervero and Landis, 1997). Two main disconnects come out of reviewing the aims and outcomes of the BART system. No land use constraints of development accompanied the BART line, with rail stations a weak draw for new housing (Cervero and Landis, 1997; Webber, 1976). Furthermore, if people drive to passenger rail stations and the weather is inclement or they're running late, it may be common for people to stay in their cars for their entire journey. In the case of BART, focused land use with proximity or access to stations was never provided by the government through housing development or policy restrictions on development elsewhere.

The BART's modest influence on land use patterns, with the beneficial impacts of rail attracting focused development were confined to central business districts of downtown San Francisco, downtown Oakland and a handful of suburban stations (Cervero and Landis, 1997). Suburban development of office space far outstripped development near BART (Cervero and Landis, 1997). Transport and land use development are multi-faceted and complex and Cervero and Landis make the case that proximity to rail stations by itself is not enough to focus growth. Rail and transport development must be associated with a land use policy that supports rail and focuses growth (Cervero and Landis, 1997).

A growing body of literature has criticized park and ride as a transport strategy. One criticism is that park and ride stations do not reduce congestion (Dickins, 1991) and may even increase congestion, fuel use and emissions by encouraging people to drive due to the availability of parking (Meek et al., 2011; Mingardo, 2013). Available parking at park and ride stations can even move people from using non-motorized or more sustainable modes to driving, for their trip to the rail station (Mingardo, 2013; Parkhurst, 1995).

In some cases, park and ride does decreases vehicle miles travelled but it depended available alternatives (Duncan and Cook, 2014). For example, as distance from the city centre increases so does the increase of vehicle miles travelled if the park and ride station was taken away (Duncan and Cook, 2014). In pedestrian friendly areas near a central business district there would be no change in vehicle miles travelled (Duncan and Cook, 2014).

In the Los Angeles context, with personal car use as the norm, moving drivers to the train is integral to any sort of passenger rail success therefore many stations are of the park and ride configuration or have nearby parking as a planning priority. Some of these parking lots are planned to be phased out in favour of mixed-use development. That has been the case at the North Hollywood station during the writing of this thesis. Until then, park and ride stations remain necessary for many passenger rail neighbourhoods in Los Angeles.

In a study of Oxford and York, park and ride stations did attracts users (Parkhurst, 1995). However, some users switched from more sustainable or non-motorized modes to the car because of the available parking (Parkhurst, 1995). Some others were even making additional trips and using the free parking for other trips not associated with rail travel (Parkhurst, 1995). At the same time, congestion remained persistent and the fear was that park and ride stations actually increased traffic (Meek et al., 2011). Park and ride may even be exacerbating congestion, fuel use and emissions in the places they examined (Meek et al., 2011). In economic terms, parking at stations reduces the generalized cost of travel, meaning that people would drive to stations because of the ease of parking instead of walking, cycling or car-pooling (Meek et al., 2011).

A study of Rotterdam and The Hague found that people that previously commuted by transit for their entire trip, drove to park and ride stations when they became available (Mingardo, 2013). In this case, people that made partial or whole trips to work by bicycle now drive to park and ride stations (Mingardo, 2013). The parking spaces made trips more economical and subsequently people made more trips overall (Mingardo, 2013). People used the park and ride lots for parking for other trip types (Mingardo, 2013). Only one quarter of people responded that it changed their trip from a full drive to a park and ride trip (Mingardo, 2013). Unfortunately, planners depend on mode shifts from complete auto trips to park and ride in order to gain reduced congestion and emissions. Sadly, Mingardo found in this study that the park and ride systems showed a net increase in traffic and not a reduction (2013).

Research of park and ride conditions near light rail lines in the United States context found that the reduction of vehicle miles travelled is most dependent on how people would travel otherwise (Duncan and Cook, 2014). In some cases, park and ride stations can reduce vehicle miles travelled and air pollution (Hammarstrom Dobler et al., 2017). Reduced vehicle miles travelled was most substantial as distance increased from the central business district (Duncan and Cook, 2014). Park and ride stations attracted higher income suburbanites and there was a net reduction of vehicle miles travelled (Duncan and Cook, 2014).

An estimation of parking spaces needed at train stations found that one parking spot attracted only 1.12 passengers (Vijayakumar et al., 2011). However, passengers were more sensitive to reliable train service patterns than available parking (Vijayakumar et al., 2011). Chester and Horvath (2009) explain that the biggest event of environmental benefit comes from people taking the train instead of driving. Park and ride stations may negate many of the catalytic and indirect benefits of railway stations. These are the benefits that make passenger rail lines a net positive and must be factored into park and ride strategies.

2.1.7 Sustainable Mode Connections

Other more sustainable connecting modes have also been studied including how bicycle sharing programs affect public transport use in New York (Brakewood et al., 2015). More research needs to be done on bicycles as a connecting influence on public transport ridership to determine how bicycles, or aspects of the bicycle realm, impact public transport ridership. The attraction of passengers and improvements of effectiveness of bicycle planning remain key questions for improvement (Zhao, Deng, and Song, 2014). Regression shows the bike shares grow with scale and complexity, government expenditure and docking stations (Zhao et al., 2014). User experience factors, such as the ability to check out bicycles with personal credit cards and integrated system cards were found to increase use (Zhao et al., 2014).

In a study of bus rapid transit in New York, besides performance and speed, quality factors such as comfort, cleanliness, access, proximity of stops, real-time information, limited stops and ticket system attributes were found to impact ridership (Wan et al., 2016)

In England there are some puzzling conclusions of some areas with new light rail lines showing an increase in car ownership (Lee and Senior, 2013). One explanation for this unexpected result is that growing rail passengers are coming from buses and not cars (Lee and Senior, 2013). The more centrally located light rail line of Croydon was the exception to this trend (Lee and Senior, 2013).

Using the case of Croydon, more trips were taken to the city centre than trips away from the city centre, with destination typologies being a possible answer for this discrepancy (Lee and Senior, 2013). The city centre of London, being denser has a variety of variables that discourage car use, such as congestion and urban design factors like narrow streets, as well as large provisions of other modes such as the London Underground and opportunities for walking trips. However, this study shows the power of place, with conditions being specific to each city or context (Lee and Senior, 2013).

The long-term influences of public transport including mixed-use land uses near to stations correspond with a substantially higher rate of walking and biking trips (Ewing and Hamidi, 2014). This reduces auto travel by more than distance of a single trip because trips by walking often combine multiple destinations (Ewing and Hamidi, 2014). Trips can be consolidated in land use conditions that are mixed-use and compact or safe for pedestrians. For example, even if those that live near public transport do not use public transport, they will drive less because of compact living and walking or biking trips, instead of driving, to the local store (Ewing and Hamidi, 2014). Mixed-use neighbourhoods offer multiple opportunities. Supportive zoning policies can maximize vehicle miles travelled and greenhouse gas reduction while offering close proximity to key destinations, overlap of journeys as well as economic uplift and social benefits (Ewing and Hamidi, 2014).

In a study of Northern California, neighbourhood characteristics have a separate influence on travel rather than solely self-selection (Cao et al., 2009). In general, this research shows that neighbourhood characteristics are associated with travel decisions, especially non-motorized travel frequencies such as walking or biking (Cao et al., 2009). Mixed-use land use tends to discourage auto use and encourage the use of public transport and non-motorized modes (Cao et al., 2009). The availability of walking and biking infrastructures, such as bicycle lanes or sidewalks, are important predictors of and key for walking and biking (Cao et al., 2009). Walking and biking also are affected by the aesthetic quality and socio-economic context (Cao et al., 2009). Overall, the built environment does play a role in travel mode choice (Cao et al., 2009).

However, the counterpoint of self-selection is rarely discussed, that the built environment, including public transport, is drawing people to live in those areas (Boarnet and Crane, 2001). Built environment traffic calming measures were found to decrease vehicle miles travelled (Boarnet and Crane, 2001). In Northern California, changes in driving had significant associations with changes in the built environment (Handy et al., 2005). The built environment had more of an impact on trip lengths than trip frequencies (Handy et al., 2005). This may offer some insight for planners deciding on station locations and route paths. These relationships are more and more complex upon more detailed investigation and need more study (Boarnet and Crane, 2001).

2.2 People and Place

Transport use depends on people. As an interdisciplinary field and practice, urban design is replete with overlapping phenomena. Two major reasons promoting public transport investment and walkable urban design discussed in this thesis are related to behaviour change. Two goals of public transport include public health benefits of walking environments related to public transport and reduced consumption of energy and reduced carbon emissions associated. These are interrelated concepts and systems (Nieuwenhuijsen, 2016). The variables of cities, urban design and transport routes offer opportunities for fine-tuning a city's performance through mobility behaviour (Nieuwenhuijsen, 2016). Behaviours and access to urban amenities such as open space can have public health implications including pollutant exposure and amounts of physical activity (Mueller et al., 2017; Nieuwenhuijsen, 2016; Nieuwenhuijsen et al., 2017).

Recent advances in data collection including smart cards, or tap cards used for entry and exit of public transport, as well as advances in surveillance and census data offer new opportunities to understand the behaviour of users and for data driven design to cater to the user experience to increase efficiency and fare returns (Oliveros and Nagel, 2016; Wang et al., 2015).

In 2014, William H. Whyte's observational study was recreated in New York (Hampton et al., 2014; Whyte, W.H., 2001). The newer study shows how people's use of public space has changed over time, including more women in public space, and more men involved in shopping (Hampton et al., 2014). In this case, men and women appear to be spending more time together in public than in the original studies from 1979 to 1980 (Hampton et al., 2014). Mobile phones have proliferated since the original studies yet, they seem to allow sole people to linger more in public space (Hampton et al., 2014). In three of the four places studied in the new research showed that there was actually more socializing in public space (Hampton et al., 2014).

Urban forms are only part of the picture with personal attributes and circumstances impacting mode choices and distances travelled (Dieleman et al., 2002). Physical attributes, socioeconomics and demographics related to age, living patterns, income, minority or immigrant populations have all been found to determine public transport use (Pasha et al., 2016). Purpose of trip also affects the travel mode and distance (Dieleman et al., 2002). People find areas with other people, pedestrian features and greenery more attractive than areas with cars and parking (Noland et al., 2017). Buildings have more mixed results when studying visual preferences, likely due to variations in quality and perceptions (Noland et al., 2017). Studies on visual preferences of areas suggest an increase in pedestrian travel and a reduction in motor vehicles are preferable to people (Noland et al., 2017). The physical and psychological benefits of green infrastructure and sustainable environments to residents within them have been documented (Tzoulas, 2007). Furthermore, healthy environments can contribute to social and economic benefits for communities (Tzoulas, 2007).

2.2.1 Wealth

Recently, indicators of wealth such as incomes or home ownership have been related to public transport use (Boarnet and Giuliano et al., 2017; Dieleman et al., 2012; Nichols, 2015; Pasha et al., 2016; Wang et al., 2015). It was found that higher income people are more likely to use a car than lower income people and to use more energy in general (Dieleman et al., 2012, Hickman et al., 2015). Of personal characteristics studied, car ownership was found to be an important variable of mode choice (Dieleman et al., 2012). Private car ownership is now accessible for millions of more people through more affordable cars and a rising middle class in many countries (Dulal et al., 2011). At the same time, emissions from the transport sector are rising rapidly (Dulal et al., 2011). Reductions in fare costs have shown increases in public transport ridership (Gong and Jin, 2014; Redman et al., 2013). It follows that external rising costs of auto use might also increase public transport ridership. The ability to buy tickets with personal credit cards or having system wide integrated cards have also shown connections to increased ridership (Zhao et al., 2014).

2.2.2 Access

Access or accessibility refers to the connectedness of a place (Brand, 2013). Access refers not only to the connections of the place but the opportunities of the place (Brand, 2013). Access to key destinations is the purpose of travel while increasing speeds of travel have led to more destination choices (Nichols, 2015; Metz, 2013). Access may be described as a combination of transport and spatial configuration (Metz, 2013). The common availability of the car has increased speeds of travel and distances of travel, which has subsequently increased choices or accessibility (Metz, 2013). Access and egress of stations are a crucial part of increasing ridership (Nichols, 2015; Tabassum et al., 2017). When given options in transport and when people are able to be within close proximity to their destinations, people actually do drive less (Handy et al., 2005).

However, the provision of access or connections is often unequal (Brand, 2013). Mobility has many facets, including social, cultural and economic factors and is made from possibilities or access to infrastructure, user competencies and how the system itself is used (Brand, 2013). All of these factors have implications for the environment. Different modes of transport are forms of physical access that interplay with economic considerations, through costs. Areas with poor public transport access use significantly more energy in transport (Hickman et al., 2017). Vehicle miles travelled is strongly related to lack of public transport access (Ewing and Cervero, 2010). Meanwhile, walking is strongly related to street network design, proximity to public transport and land use diversity (Ewing and Cervero, 2017).

While employment centres often drive ridership numbers of passenger rail, they also play a large role in vehicle miles travelled (Boarnet et al., 2016). United States transport planning has focused on the car and mobility, reaching destinations further away and faster, rather than accessibility (Proffitt et al., 2017). The true end goal of transportation is accessibility, increasing opportunities for people to meet their daily needs (Proffitt et al., 2017). While significant barriers still exist, there is evidence that accessibility is gaining prominence in theory and practice (Proffitt et al., 2017).

Many of the benefits of increased public transport are the result of accessibility and agglomeration (Banister and Thurstain-Goodwin, 2011). These include, better access to public goods and increased proximity of firms and supporting businesses to each other. In fact, a large number of the benefits of public transport are not internalized within the transport system. The relationship between complexity, agglomeration, walkability and the benefits of public transport make for an interesting yet problematic study because of the challenge of dispersion that must be overcome.

2.2.3 Pedestrian Experience

Every transit user is a pedestrian (Mees, 2010). Other modes that integrate the pedestrian include, public transport and cycling and are largely agreed to be more sustainable modes than private car use (Redman et al., 2013). Data mining of transit cards, or tap cards, for public transport has led to a variety of conclusions on the relationships between urban quality factors that impact pedestrians and ridership (Van Oort et al., 2015). Reducing fares, or increasing costs of auto use, and other habit interrupting measures have been found to succeed in users trying public transport initially however, attributes beyond accessibility and reliability, including the quality of the pedestrian user experience must be maintained (Redman et al., 2013). Service quality for the passenger has been found to improve ridership of public transport (Cascetta and Carteni, 2013).

Recently quantified is the urban design of pedestrian access in neighbourhoods and their encouragement of public transport ridership (Badland et al., 2017; Boulange et al., 2017). Mode choices of walking, cycling, public transport and the private car have been found to relate with urban design attributes (Boulange et al., 2017). Furthermore, environments that encourage, walking, cycling and public transport have been found to discourage car use (Badland et al., 2017; Boulange et al., 2017).

Positive relationships between the more sustainable modes of travel have been found with housing diversity, dwelling density and proximity to supermarkets (Boulange et al., 2017).

Urban design for pedestrian connection with public transport has mutual benefits including upward social mobility. Neighbourhood, place or context has been proven to affect the upward mobility of individuals, with access to amenities related to earning potential and opportunities (Chetty et al., 2015; Rothwell and Massey, 2015). Place matters in terms of intergenerational upward mobility (Chetty et al., 2015). Many people in cities don't have cars because they can't afford them. Recent immigrants are likely to use public transport (Ganning et. al, 2015). Access to urban amenities, institutions and services, including and via public transportation are fundamental to these processes. In fact, economic segregation depresses upward mobility across generations with strong negative effects on future earnings (Rothwell and Massey, 2015). Accessibility to services and amenities, including by public transportation, affects a child's success by up to half the effect that parental income has on a child (Rothwell and Massey, 2015).

Perceived travel time, reliability, cost and comfort are some of the most important factors in public transport use (Van Oort et al., 2015). However, human comfort is not commonly studied in travel demand research (Van Oort et al., 2015). While regular users have been found to be more resilient, variations in environmental quality have been found to play more of a role in off peak travel (Zhou et al., 2017). Adjusting for weather and poor environmental quality including adding architectural shelter elements are ways to encourage non-regular users and improve off peak travel. Furthermore, not considering capacity and pedestrian comfort in travel demand studies have led to an under prediction of the effects of transport policy (Van Oort et al., 2015). A study of Tempe, Arizona found that more pedestrian environments between business and residential buildings created beneficial outcomes for preventing low ridership, even in low density conditions, for better environmental goal achievement (Hammarstrom Dobler et al., 2017).

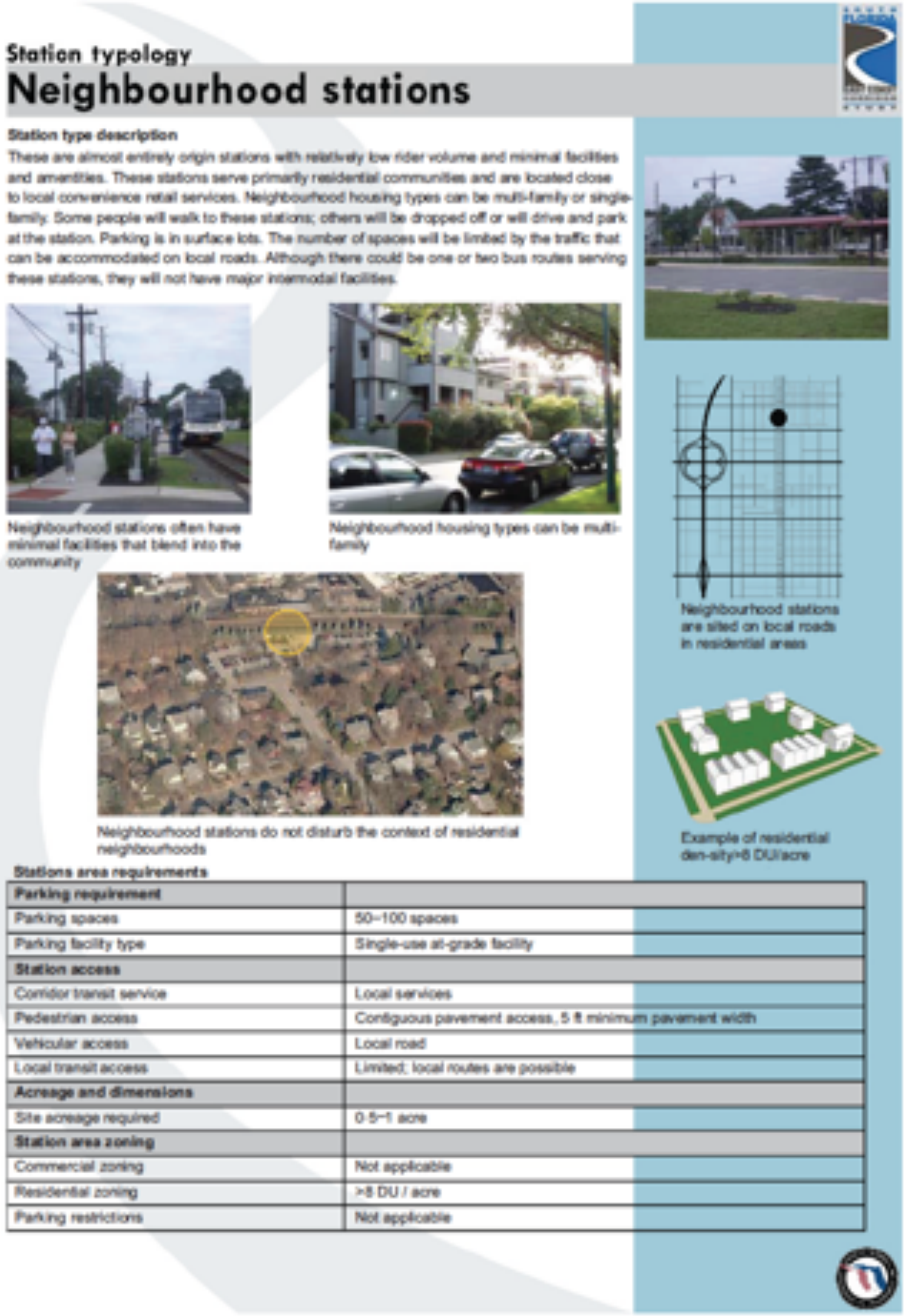
2.3 Typologies and Operationalisation

Types or criteria of good design are ways to make use of previous knowledge discussed on the relationship between the built environment and passenger rail use (Banerjee, 2002; Harris, 2008; Lynch, 1966; 1972). Stations and station areas can usefully be categorized into types in order to identify how parts generate or respond to different changes. Common aspects of stations and station areas examined in this way are station design development, access and land use (Ganning et al., 2016; Payton and Hawkes, 2013). Types provide a link from analysis or description to design and prescription.

As a means of ordering entities, the use of classification, taxonomy and typologies are central to our daily lives (Bailey, 2003). A strict distinction between taxonomies and typologies would demarcate taxonomies as based in empirical data while typologies are qualitative in nature born from the verbal and conceptual (Bailey, 2003).

Transport agencies and municipalities are looking for ways to make transport planning more sensitive, or accurate, to urban conditions (Payton and Hawkes, 2013). These architectural or physical typologies can be used to identify key urban design issues and to make urban design recommendations (Payton and Hawkes, 2013). Passenger rail station design is composed of a set or system of types that may make for a good station or higher passenger rail use including a taxonomy of types of entries, exits, paths, heights etcetera (Marshall, 2005). Architectural typologies are useful visual tools to communicate a vision, intent or station design concepts (Payton and Hawkes, 2013). Visual types can be used to make new design implementations consistent with the character, density and image of a place and potentially create standardized outcomes (Payton and Hawkes, 2013). Furthermore, typologies can be agile, used to visualize passenger rail station forms, density and character through a cross section of the city that shows different types of stations in different types of context, from dense urban conditions to suburban contexts

(Payton and Hawkes, 2013). A standardized yet flexible system of types can be used along rail corridors to be place specific and calibrate land uses and building forms near stations (Payton and Hawkes, 2013).



Station typology

Neighbourhood stations

Station type description

These are almost entirely origin stations with relatively low rider volume and minimal facilities and amentities. These stations serve primarily residential communities and are located close to local convenience retail services. Neighbourhood housing types can be multi-family or single-family. Some people will walk to these stations; others will be dropped off or will drive and park at the station. Parking is in surface lots. The number of spaces will be limited by the traffic that can be accommodated on local roads. Although there could be one or two bus routes serving these stations, they will not have major intermodal facilities.

Neighbourhood stations often have minimal facilities that blend into the community

Neighbourhood housing types can be multi-family

Neighbourhood stations do not disturb the context of residential neighbourhoods

Neighbourhood stations are sited on local roads in residential areas

Example of residential den-sity>8 DU/acre

Stations area requirements

Parking requirement	
Parking spaces	50–100 spaces
Parking facility type	Single-use at-grade facility
Station access	
Corridor transit service	Local services
Pedestrian access	Contiguous pavement access, 5 ft minimum pavement width
Vehicular access	Local road
Local transit access	Limited; local routes are possible
Acreage and dimensions	
Site acreage required	0·5–1 acre
Station area zoning	
Commercial zoning	Not applicable
Residential zoning	>8 DU / acre
Parking restrictions	Not applicable

Figure 1. An example of a detailed neighbourhood typological analysis and proposal of station area requirements based on the context with qualitative and quantitative information similar to a case study (Payton and Hawkes, 2013).

Typologies in urban design and transport are useful for a few reasons, firstly, identifying key issues and responding to urban design or forms that are consistent with the local character (Payton and Hawkes, 2013). After identification, typologies may also be operationalized to inform development at station entrances or in the surrounding areas (Payton and Hawkes, 2013). Thirdly, typologies can be used to develop a vision for the future (Payton and Hawkes, 2013). Typologies can also be used to show how different visions or scenarios might have different outcomes, such as different station types affecting different levels of passenger rail ridership, impacts on the environment or economic instigation (Carmona et al., 2010; Ganning et al., 2016; Payton and Hawkes, 2013).

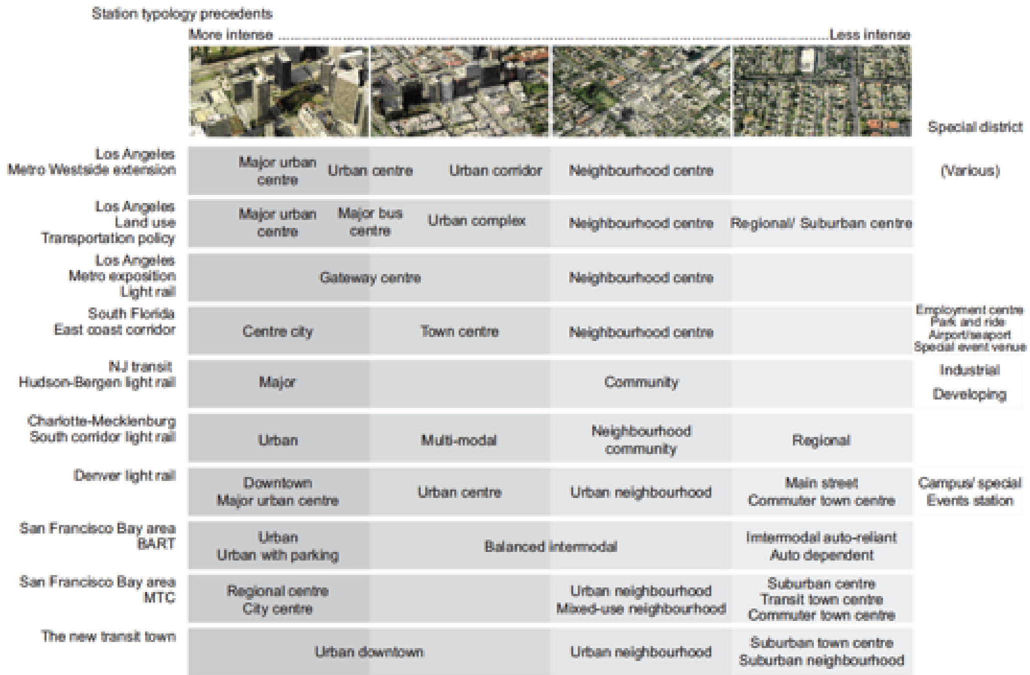


Figure 2. An example of using typologies in analysis for transport corridors and station areas at different scales (Payton and Hawkes, 2013).

One size fits all or singular visions of the city have been problematic or failures so far, and more current efforts respond to the identity of place but would also benefit from an agile design, from a kit of parts or a tool box that could provide a range of choices for use in new situations (Duany, Speck, and Lydon, 2010; Hawkes and Sheridan, 2009; Payton and Hawkes, 2013). Beyond one type of station, typologies offer flexibility and nuance in the process for a larger vision with urban form more tailored to place (Crawford, 2004; Payton and Hawkes, 2013).

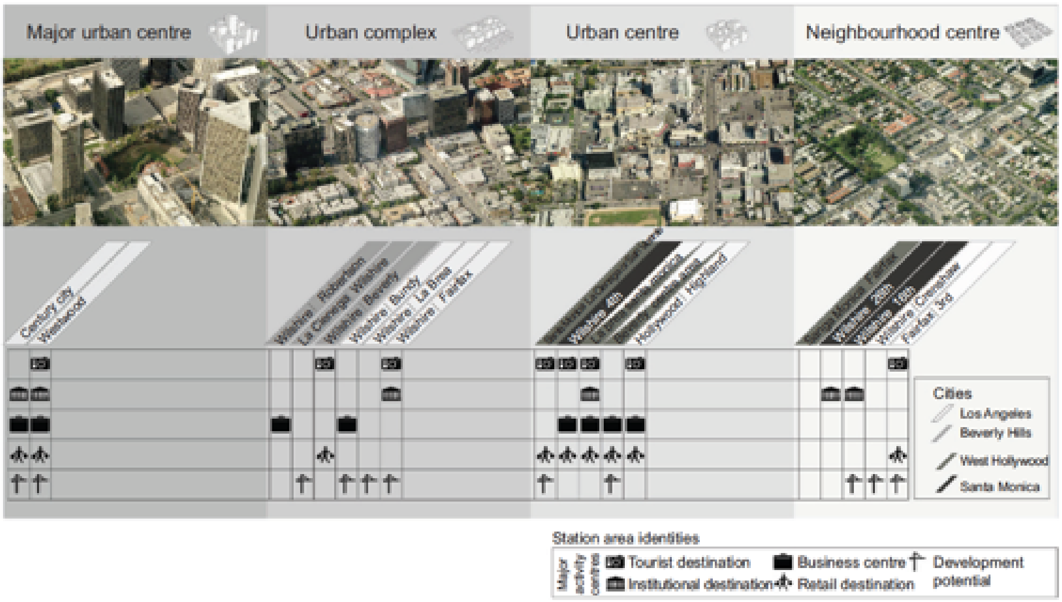


Figure 3. The development of typologies based on site analysis, with the emphasis on using typologies to express real cases before proposing types of stations for these cases (Payton and Hawkes, 2013).

Transport corridors may be branded to unify the corridors from a careful investigation into who will ride at specific stations, how development will occur over time near stations, and attention paid to tourist centres, shopping areas, residential zones and business districts as well as how the station itself is built and organized (Payton and Hawkes, 2013). Essentially, the formation of typologies contains three main elements, including the user, the passenger rail station and the place where it is located.

Typologies can be operationalized through surveys or worksheets like those used by Jan Gehl, Project for Public Spaces and the New Urbanists (Carmona et al., 2010). Components in the use of typologies in urbanism have included ethical principles, area density, housing types, land use mixtures, materials and transport connections amongst many others (Carmona et al., 2010; Payton and Hawkes, 2013). Eventually, specific forms or distances could possibly be associated with passenger rail use (Payton and Hawkes, 2013).

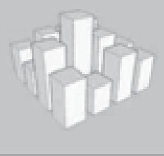
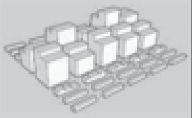
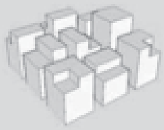
	Typology	Density	Scale	Station entrances	Station portal type
Major urban centre		High	High-rise Mid/high-rise Mid-rise Low-rise	At least three	Joint development restricted right-of-way Existing building intermodal transportation centre
Urban corridor		High along the corridor Low/mid-rise to mid-rise adjacent	Mid/high-rise along the corridor Mid-rise adjacent	At least two	Plaza Joint development restricted right-of-way existing building intermodal transportation centre
Urban centre		Mid Low/mid	Mid/high-rise Mid-rise	Two preferred	Plaza Joint development restricted right-of-way existing building
Neighbourhood centre		Low/mid Low	Mid-rise Low-rise	One or more	Plaza Restricted right-of-way

Figure 4. A simple operationalized typology where density and scale determine how many entrances and what kinds of entrances are needed for passenger rail station design (Payton and Hawkes, 2013).

2.4 Literature Review Summary

The literature review has focused on three components of public transport, the place or built environment, people’s interaction with public transport and finally how to operationalise typologies and urban forms for public transport use. The key issues found include density as an indicator of transport use, the behaviour of users of park and ride stations, urban design and mixed-use environments as proponents of passenger rail use and the importance of understanding the relationship of context to station activity and ridership numbers (Meek et al., 2011; Mees, 2010; Mingardo, 2013; Parkhurst, 1995; Vijayakumar et al., 2011). Park and ride stations remain a common strategy of new rail line planning despite mixed results in transferring drivers to riders (Mingardo, 2013; Vijayakumar et al., 2011). Density is also a common variable in the study of transport planning and thought by many to be an indicator of public transport use (Cervero and Kockelman, 1997; Melia et al., 2011;

Zegras, 2004). Mode choice, or encouraging people to use passenger rail instead of less sustainable modes of travel is key to environmental benefits (Chester and Horvath, 2009). The design or urban form of station neighbourhoods are vital for mode shift to more sustainable modes, environment and public health improvements (Badland et al., 2016; Boarnet et al., 2016; Cass and Faulconbridge, 2016; Dulal et al., 2011; Giles-Corti et al., 2013; Pasha et al.,2016). Pedestrian experience or walkability is fundamental for environmental and public health gains related to public transport (Camacho et al., 2016; Clifton and Handy, 2001; Frank et al., 2015; Lindholm and Behrends, 2012; Mars et al., 2016; Sallis et al., 2016). Several remaining research gaps have been identified for further study.

2.5 Research Gaps

- Understanding User Experience in Public Transport

Existing literature on land use and transportation focuses on the passenger's travel but not necessarily their experience or the quality of their journey (Boarnet, Hong, and Santiago-Bartolomei, 2017). However, land use design and amenities are an integral component of public transport success, catalytic development and the multiplication of benefits (Guerra and Cervero, 2011). This relationship must be investigated and argued further (Beauregard, 2006; Beauregard and Marpillero-Colomina, 2011; P. Hall and Pain, 2006).

Recently, there have been more and more calls for research into and for an understanding of the experiential process of case study research in transport planning (Camacho et al., 2016; Hampton et al., 2015; Hickman et al., 2015; Straatemeier et al., 2010). A focus on the pedestrian and the users in transport planning, rather than the mere movement of units, has been recommended (Ksiqzkiewicz, 2012). Research into travel and urban form has been limited by trip analysis because it has not traditionally considered combined trip travel, that is commonly the nature of more sustainable modes of travel like walking and bicycle trips (Krizek, 2003).

Many questions remain regarding how demographics, land use and urban design relate to mode choice and passenger rail success (Hickman et al., 2015). A passenger centric approach is necessary to enhance public transport service and to draw users from other modes (Camacho et al., 2016). A better understanding of how the pedestrian realm is related to passenger rail use is also needed (Schlossberg and Brown, 2004). Cycling, closely related to the pedestrian environment, and to passenger rail use has also been the source of limited study (Frank et al., 2016).

Density and use are not the same thing, with transit stations now having multiple functions for multiple stakeholders such as retail (Zemp et al., 2011b). Yet analysis merely of functions is also insufficient and broader tools to understand relationships between development and passenger rail transport are needed (Reusser et al., 2008).

- Understanding the Interaction and Complexity of Predictor Variables

How transport variables interact is another source of needed inquiry (Cervero and Guerra, 2011; Duffhues, 2016; Harding et al., 2013). Relationships between transport and land use remain complicated and an intense source of study with moving parts, variable outputs, direct and indirect costs and benefits (Duffhues, 2016). More understanding of how these vast aspects of context and how context plays a role in cities, policy materialisation and planning is needed (Harris, 2008; Hillier, 2011; Robinson, 2011; Rydin and Natarajan, 2015). Relationships between health, the built and natural environments need to be examined to determine their links, weights and scalar phenomenon in order to target their actions and fine tune the variables of cities for better health and environmental performance (Nieuwenhuijsen, 2016).

- More Variables and Cases Needed in Assessment Models

Multi-criteria approaches have been called for and are a burgeoning avenue of transport research (Rode, 2018). Both qualitative and quantitative methods are needed to explain transport processes (Ksiqzkiewicz, 2012). The problem being studied should ideally dictate the method of research with qualitative methods answering research questions about quality (Ksiqzkiewicz, 2012). The outcomes of transport interventions are the result of hybrid processes and it follows to use hybrid research methods to study them (Rode, 2018). These complicated relationships are often investigated via case study methods facilitating a more holistic composition of these complex behaviours (Hull, 2008; Yin, 2003).

Our current understanding of the built environments' impact on railway stations is limited and a better understanding is surely needed (Bertolini et al., 2012; Chorus and Bertolini, 2011; Papa and Bertolini, 2015). Many recent articles include a call for more performance and context indicators in the study between places and passenger rail (Papa and Bertolini, 2015; Kamruzzaman et al., 2014). More case studies have been deemed necessary (Duffhues and Bertolini, 2016; Bertolini et al., 2012).

The academic literature on both travel and physical activity largely ignores urban design streetscape features (Ewing et al., 2016). This is partly due to high labour costs of first person field-work (Frank et al., 2016). However, safer pedestrian environments are needed for sustainable travel modes such as walking and cycling. The only way these environments will be fine-tuned or researched, is through the pedestrian first person perspective (Frank et al., 2016).

- More Progress in Assessment Models

New research models are needed to evaluate station areas, or catchment areas, in terms of transport, land use and urban design (Vale, 2015). Few have empirically identified the benefits of transit-oriented development typologies in a quantitative manner (Bertolini et al., 2012; Kamruzzaman et al., 2014). There is a lack of assessment models regarding participation in the urban realm and more are needed (Nieuwenhuijsen et al., 2017). Specifically, better modelling of pedestrian networks including place elements such as sidewalks, intersections and street classifications (Schlossberg and Brown, 2004). Further research tools of this type for understanding the relationship between context and the functions of railway stations are also needed (Bertolini, 1999; Reusser et al., 2008; Vale, 2015; Zemp et al., 2011b). How to create more accurate predictions would be beneficial to transport planners (Bertolini and Chorus, 2011). Furthermore, there is standardisation that is necessary in assessment models in order to compare cases in different cities (Frank et al., 2016). Consistent objective measures of the built environment are needed, including international comparisons in order for greater connections between the built environment contexts and travel behaviour (Frank et al., 2016).

Expansion of research models, especially to include more variables or attributes of essential functions need to be included in this transport analysis and this thesis attempts that with the inclusion of site analysis, or human scale, data and many more census variables than have been used before (Zemp et al., 2011a).

- Policy Barriers Identification

The implementation gaps between research, policy and transport outcomes must be investigated (Chorus and Bertolini, 2011). This requires an examination of policy barriers specific to national and local context (Duffhues, 2016). A better charting of planning aims and inconsistences has been identified for improvement in transport research (Duffhues and Bertolini, 2016). Decision makers need better data on the complexity of urban factors in environmental processes that affect human health (Nieuwenhuijsen, 2016). The materialization of transport policy and actual outcomes must be audited and analysed.

3 Research Strategy and Methods

3.1 Mixed-Methods Case Studies in Transport

This thesis focuses on how place, made up from many different variables affects ridership in Los Angeles, Berlin, Hong Kong, London and Medellin. Passenger rail is being promoted and implemented worldwide with many benefits being touted, including better public health, economic catalysis and an improved environment. However, transit-oriented development, or land use change is key to these benefits and the success of passenger rail by reinforcing pedestrian access. Therefore, this thesis investigates the context, or surrounding area features, and their impact on passenger rail ridership. This chapter presents the research methods used and data sources, for the cases of Los Angeles, Berlin, Hong Kong, Medellin and London.

3.1.1 Chapter Structure

This chapter explains the investigation of place and passenger rail, through background and content analysis, statistical analysis and with case studies. Dependent variables of this thesis and statistical analysis are described as station area and station passenger rail ridership numbers. The selection of the case studies is briefly described. The case study cities are introduced starting with the most detailed case Los Angeles followed by introductions of Berlin, Hong Kong, London and Medellin. The data collection and data analysis of each case study city are explained. Three main forms of data are triangulated including text analysis, statistical analysis and place site analysis. These three research vantages provide insights that might be neglected by any one method and for the conclusions of how these different methods complement each other. Finally, typologies are presented as a method of generalizing or operationalizing conclusions on how specific types might behave or operate.

3.1.2 Research Questions

Problem and Task: Public transport passenger rail lines and hubs are being constructed to adapt to challenges of auto congestion and many social and environmental challenges such as poor public health including obesity and pollution. Land use change and cognisance of its relationship to passenger rail success has been largely neglected, as a strategy yet, is an integral component for passenger rail ridership and the return of public health benefits (Camacho et al., 2016; Cervero and Dai, 2014; Cervero and Duncan, 2002; Cervero and Kang, 2011; Ingvardson et al., 2017).

Hypothesis:
The design of passenger rail transport stations and their destination place, or context, has an effect on passenger rail trip numbers. In this way, context affects the benefit return of passenger rail through encouraging or discouraging riders at stations.

These research questions are explored in order:

1. From a sample of interviews and planning documents, how and to what extent is transit-oriented development included in transport planning in Los Angeles (see Chapter 4)?
2. How are place attributes of passenger rail stations associated with higher passenger rail ridership?
    a. What context or place attributes of a station area, including transport connections, demographics, station design elements and travel behaviour of residents, have bivariate correlating relationships with ridership, in Los Angeles (see Chapter 5)?
    b. Of the correlating relationships found, which have a significant impact on ridership viewed from a multiple regression in Los Angeles (see Chapter 5)?
3. What can site analysis tell us about these station areas in Los Angeles and how does site analysis research complement traditional statistical analysis in transport research (see Chapter 6)?

4. With the site analysis approach developed in the Los Angeles case, are there similar relationships between station area design attributes and passenger rail ridership evident in Berlin, Hong Kong, London and Medellin (see Chapters 7, 8, 9 and 10)?

3.1.3 Cities Case Study Selection

Considering the complex relationships of the variables that have an effect on passenger rail ridership a case study of qualitative methods supported by statistical modelling was necessary for more holistic understanding (Flyvbjerg, 2006; Yin, 2003). Case studies are used to answer how or why questions (Yin, 2003). Boundaries between context and phenomena are not always clear (Yin, 2003). A case study can be used to investigate a contemporary phenomenon in depth and within a real context (Yin, 2003). Multiple methods provide a comprehensive approach (Yin, 2003). The remainder of the chapter describes the mixed method case study strategy organized by case study city, beginning with the interviews and document analysis.

Comparative case study analysis is commonly used in urban transport research. Cases are often situated within their political economy and geography (Fainstein, 2005; Salet, 2008). A qualitative analysis of passenger rail projects is necessary, as the effects of these projects tend to be multi-layered and cross-disciplinary. Furthermore, comparisons travel across different policy, cultural, and built contexts and comparable data is difficult to find in the same standards or units.

The cities used as case studies in this thesis were largely chosen for their novelty or innovation with a care for balancing them against each other. Los Angeles was the starting point for a variety of reasons. Stereotyped as the auto city, the built environment and demographics of the city are extremely diverse at the neighbourhood scale. The speed of light rail, bus rapid transit and heavy rail implementation in a democratic society with layers of public planning processes is also of interest. The train system itself has a variety of line and station configurations. The dramatic and visible land use through diverse transport and station options made Los Angeles, the auto dominated city, a fascinating case of how cities could change their land uses and transport systems to more sustainable models in the current age.

Berlin, London and Hong Kong were all chosen as exemplar style case studies with established, yet innovative, passenger rail and public transport systems. Berlin has an interesting built environment of older European mixed with modern buildings built in the vacant bombed spaces after World War Two, similar to the City of London. Berlin has a comprehensive and diverse public transport system but also integrated separate systems between East Berlin with West Berlin after reunification. The London Overground and the Docklands Light Railway were chosen as lines for analysis rather than the Underground because of their configuration through the existing built environment and because they offer a glimpse into how these lower costs systems might behave. These lines organized through an existing built environment compare with Los Angeles' contemporary efforts. Hong Kong was chosen for their innovative finance procedures and intense land use development. Hong Kong is an extreme extrapolation of land use development and transport agency as property owner. Similar albeit smaller property strategies are evident in Los Angeles. Medellin was chosen for all these reasons, configuring through an existing built environment with a lower cost light rail and bus rapid transit strategy, for their innovative finance schemes, transport adjoining developments, and for their socially minded provision goals. Medellin and Los Angeles match most closely in many ways with their social agendas, entrepreneurial strategies, their reliance on light rail and their use of passenger rail to reorganize the existing city using a diverse system architecture. This sample of five cities provides enough likeness to compare yet enough diversity for conclusions based on place, united by passenger rail as the transport mode of study.

3.2 Los Angeles

The Los Angeles case is the most detailed of the five cases. A literature review, semi-structured interviews and a planning document analysis were performed to determine if transit-oriented development and land use were topics of significant awareness, or were an agenda of Los Angeles planning professionals. The second stage is a statistical analysis that is usual in transport studies, yet the tests for this thesis include a much larger database of variables than is common. The third stage is a study of the urban quality of station areas in Los Angeles using a site analysis survey. These stages guide each other and also contrast in certain cases. These separate methods identify different aspects of transport phenomenon and illuminate different conclusions. The Los Angeles case was formative for the other four case studies.

3.2.1 Data Collection of Passenger Rail Ridership by Station Location

Los Angeles Ridership data for 2013 was obtained from the Los Angeles Metropolitan County Transportation Authority. The train system relies on samples because not all stations have turn styles or gates despite having tap card data. However, gates are being implemented where possible yet, this is still a loose implementation including unlocked gates for disabled passengers or bicycles. Light rail stations are more open than the underground stations with only tap points and not gates relying on people to police themselves and tap their card upon entry. The LA Metro used to be an honour system with transport police walking through spot checking tickets but now that is undergoing change and in the future data mined from smart cards might make for a more accurate picture of passenger rail ridership, especially in regards to the spatial implications of station entries and exits.

Passenger rail ridership for all stations used in this thesis was the total annual entries and exits per station. Los Angeles ridership data is for weekday travel. Transfers[6]

[6] Transfers and transfer stations refers to other fixed guideway public transport lines including rail, bus rapid transit and cable cars that are available at a station. The number of transfers available at a

within a station between lines could not be included or determined due to a lack of data in agency ridership tracking or estimates. The annual ridership numbers, alighting and boarding combined for a total picture of specific station activity. These itemized ridership numbers were then used in the statistical analysis to determine contextual predictors of ridership and also compared with the urban quality survey to determine whether demographics, system characteristics, individual urban design elements or categories, such as social life, correlated with higher or lower ridership.

3.2.2 Background Diagnosis: Mapping, Interviews and Text Analysis

3.2.2.1 Mapping

Two different mass transit lines in Los Angeles were mapped to judge development around station areas and issues of integration between public transport line and land use in Los Angeles. The first phase of mapping studies of Los Angeles land development near public transport took place in June and July of 2012 (Chester and Horvath, 2009; Chester and Horvath, 2010; Kennedy et al., 2011). This analysis preceded under the premise that land use and urban design are related and even integral to public transport success.

The Gold Line light rail line and the Orange Line bus rapid transit (BRT) line paths were investigated for low-density land use challenges for public transport in Los Angles including single-family housing, vacant lots and street level car parks to measure. From the shaded maps it is clear that much of the areas around these two lines are under-developed for pedestrian travel. I looked at the context of land uses and spaces surrounding the light rail line the Gold Line and the bus rapid transit line the Orange Line. Zimas, a Geographic Information System software provided by the City of Los Angeles was used to map land use, zoning, public amenities and geographic attributes of areas around these light rail and bus rapid transit stations. Work on this detailed mapping system was compared with Google Maps satellite imagery and site visits. Site visits were especially useful for understanding the

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station refers to the number of rail of fixed guideway public transport lines that a passenger may connect to.

transport stations analysed because satellite imagery may be out of date. Furthermore, some government buildings were not on satellite imagery. Not only were they not marked but these buildings were not shown to exist at all making it appear that there were large open spaces near bus rapid transit or rail stations when in reality, the built environment around these stations was more impacted and used.

The Gold Line light rail line travels from downtown Los Angeles to Pasadena and the Orange Line bus rapid transit line travels from Universal City to the northwest San Fernando Valley. These lines continue to be expanded. Some are currently being developed with mixed-use residential developments near these transport hubs, like North Hollywood station and Chinatown station. Despite these encouraging developments, the mapping study still shows a pervasive challenge for passenger rail use with low-density and vacancy within the walking perimeter of stations. These two lines were chosen because they cover a diverse path of Los Angeles areas and have been targeted for transitions to more efficient systems like light rail or underground passenger rail.

The parcels or lots were annotated in colour; red for a ground level parking lot, yellow for low density industrial, light blue for single-family housing or light violet for very low density residential such as homes on agricultural space. Yellow parcels denote low-density light industrial space. These categories were defined by the Los Angeles land use zoning code. Roughly, a quarter mile radius was analysed over the official land use maps to note vacant or very low use parcels or lots in the general tradition of prior transport research that uses .25 or .5-mile radius as metrics of analysis (Guerra et al., 2012).

The study took place between June 25 to August 25 while I was hosted by the University of California Los Angeles Institute of the Environment and Sustainability with supervision from Professor Stephanie Pincetl at the institute and Professor Mikhail Chester of the Arizona State University School of Sustainable Engineering and the Built Environment. Site visits were a key part of this diagnostic mapping and were carried out on work days between June 25 and August 25 with weather being very sunny and temperatures ranging from the June 25th low temperature of 14 and high temperature of 25 degrees Celsius to August 25th that had lows of 18 and highs of 28 degrees Celsius.

The most typical and novel cases of the 21 stations of the Gold Line surveyed and mapped are discussed in this thesis. The Gold Line light rail line covers 3 cities, Los Angeles with 10 stations, Pasadena with 6 stations, South Pasadena with 1 station and 4 other stations in Los Angeles County in unincorporated areas. The Orange Line bus rapid transit runs through the City of Los Angeles boundary with 14 stations being mapped, for a total of 35 stations.

This study of the context of these public transport stations is useful to compare this larger scale of mapping with the more detailed statistical analysis that follows and brings to light general issues of the land use side of the relationship between place and public transport. In particular, this mapping of the place conditions complements the discussion of transit-oriented development priorities of Los Angeles transport agencies because of the visible vacancies of space around the stations that this mapping component brings to light. This first phase of mapping diagnoses the scarcity of supportive built environment surrounding many stations in Los Angeles.

3.2.2.2 Interview and Document Analysis

A policy context is necessary for analysing the planning potential of transport and urban design (Boarnet and Crane, 2001). Transit-oriented development has been a promising means of physically reorganizing cities and can be a policy context as well as a typology of building or city structure.

Semi-structured interviews using a list of questions on land use and public transport were performed with 13 planning professionals, academics and architects concerning the Los Angeles Metropolitan Transportation Authority (LA Metro) system. These interviews identified a passive transit-oriented development strategy. Interviewees were selected for their involvement in the creation, organization or study of the LA Metro system. Seven official city planning professionals for municipal transport or planning agencies were interviewed, three academics researching land use and passenger rail were interviewed, and three practicing architects or urban designers were interviewed. The boundaries between public or private practitioners and academics is blurred because the architects and agency officials teach from time to time in different capacities. These were considered key informants due to their participation in station land use development projects and pedestrian centred design surrounding passenger rail stations in Los Angeles.

Planning officials from the Los Angeles Department of Transportation, the Los Angeles County Metropolitan Transport Authority and the Los Angeles Department of City Planning were interviewed. The focus was on joint-development or transit-oriented development above and around Los Angeles County passenger rail systems. Interview questions contained three thematic parts, the current state of Los Angeles passenger rail projects and development, the policy or processes of developing or designing station areas, and finally a portion involving the personal expertise of the interview subject and opportunities for acquiring more data. Interviewees did not request anonymity but most preferred not to be quoted. Their professional title suffices to identify their role and perspective on the transport systems. For the purposes of this thesis it is not necessary who said what, rather what was said, what topics were circulating in planning circles, and what topics were promoted. The list of interviewees, the consent form and the interview questions are detailed in Appendix A.

Interviews lasted between 30 minutes to one hour approximately. Interviews identified areas of contention and interest for further study. In general, Interviewees seemed eager and comfortable talking about their current projects, efforts and procedures. All of these interviews were done at the official’s office, with the exception of one interview being by phone and one interview at a cafe. Most interviewees directed me to further resources and information. Interviews were recorded with note taking and an audio recorder.

There were two substantial research visits in addition to short visits for conferences in Los Angeles. I worked at the California Center for Sustainable Communities, of the Institute of the Environment and Sustainability at the University of California at Los Angeles in the summer of 2012. I remained in regular contact with professors there through December 2012 to discuss this work. The second extended stay was in 2013 at the Environmental Compliance and Services Department (ECSD) of the Los Angeles Metropolitan Transportation Authority. Both research visits were approximately ten weeks. A shorter three-day stay was conducted at the Arizona State University to research sustainability issues in land use and public transport. These longer stays enabled me to speak much more often to host experts, to follow up on questions and to be introduced to data source and other stakeholder for interviews.

From the 13 interviews a list of 56 recurrent terms were identified manually and collected for further study via a document content analysis. This analysis uses a directed approach beginning with ideas of which terms might be included in the planning documents from interviews and literature review (Hsieh and Shannon, 2005). These key terms could be considered priorities, aims or concerns. These terms were used to search 19 planning documents and reports from Los Angeles planning authorities for concurrent official term inclusion in planning literature. These planning documents and reports focused on transport, the environment and included general or master plans. These collected documents were downloaded and processed through NVivo qualitative data analysis software. The wide number of terms selected from the interviews were then ranked from the most mentioned terms to the least referenced. This content analysis identifies explicit references of key terms in Los Angeles planning to determine the relative amount of attention and promotion these terms and concepts were receiving. The planning documents analysed are detailed in Appendix A.

The wide range of 56 terms, or codes, were inputted and analysed using NVivo 12 qualitative data analysis software. A search of 19 strategic planning documents that were available to the public by download was conducted with each of these 56 codes. The planning documents include the LA County General Plan, 2015, the LA City Mobility Plan 2035, 2014 and LA Metro long-range and short-range transportation plans. The 56 codes include terms such as density, urban design, land use, development, transit-oriented development and affordable housing. The software outputs a list of the number of code mentions. This type of analysis and the resultant outputs have been used to show how specific concepts are integrated within planning systems (Kabisch, 2015). Content analysis has been used to identify gaps between what is promoted and what is the outcome of policy (Geneletti and Zardo, 2016; Woodruff and BenDor, 2016).

Terms from the document analysis are compared with occurring terms from the interviews and set the stage for a comparison between promoted topics in planning documents and built outcomes of transport policy. While transit-oriented development or joint development were discussed in the semi-structured interviews, the planning documents revealed less of a priority on land use development and more of a recurrence of transport mode terms such as bicycles or cars. This light promotion or priority of the necessary land use development in association of passenger rail lines in Los Angeles identifies a sufficient land use strategy absence in transport planning. This spurs the research of this thesis to identify relationships between station areas and passenger rail ridership. The following statistical analysis investigates surrounding land use development and urban design with passenger rail ridership performance in Los Angeles.

3.2.3 Bivariate Pearson Correlation and Multivariate Linear Regression

Census data was accumulated through the United States Census, the majority of which is dated as a 2014 estimate based off the 2010 Census. Age, employment, education, foreign birth and availability of cars were some of the variables found for areas that the transport stations were in. These variables came packaged by ZIP code of the train station or, in a few cases, by a census block. However, variables were always consistently in one or another. ZIP code areas are based upon the post office's delivery ability, roughly a measure of service, distance and density. Census data was most useful for describing the station area demographics, employment context and travel patterns of the population. Site surveys and interviews were most useful when incorporating station technology and architectural design into statistical variables such as available parking spaces, below or above ground orientation and terminal, through, or transfer station.[7] Indicators from other organizations were used to gain information and to double-check the regression of this thesis but were convoluted with their own variables making detailed use in the regression of this thesis tricky. However, they were useful to understand their relationship with ridership, such as walk score, bicycle score, and pollution burden to name a few. These other metrics were obtained from walkscore.com, zillow.com, the California Communities Environmental Health Screening Tool, the University of California at Berkeley, Center for Law, Energy and the Environment and the Center for Neighbourhood Technology. All of these variables were tested for their correlation with and impact on ridership.

[7] Terminal stations or end stations refer to the end of a rail line without the opportunity to transfer to another rail or fixed guideway public transport including bus rapid transit and cable cars.

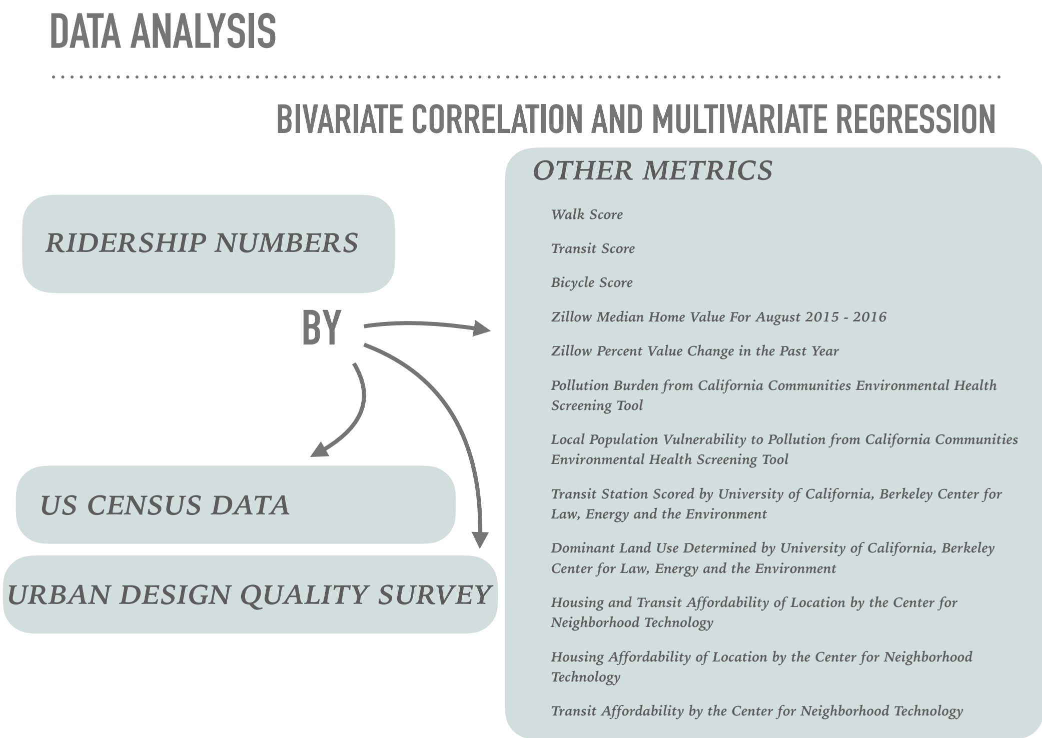

Figure 5. Data sources and organization of statistical analysis diagram for the Los Angeles case including station design factors usually neglected in transport analysis.

3.2.3.1 Bivariate Pearson Correlation Analysis

A large data set was built with data from the site visits and surveys, the ridership numbers for individual stations from appropriate transport agencies, United States Census data and secondary source metrics for the Los Angeles case. The dependent variable was the ridership total, with the station name or location being the case number. This study is a much more expanded study than the previous land use mapping study. Sixty-six variables were put against ninety-one station areas. Some stations are transfer stations or multi-line stations, even with separate turn style exits and it seems appropriate to separate them. This data set of 91 by 66 was put through a statistical correlation analysis via IBM Statistical Package for the Social Sciences (SPSS). Only found relationships are discussed with this thesis. That is not to say relationships not found for this research mean there are none between certain variables but, rather that they require more research or different models to analyse them.

The principles behind correlations, or modelling relationships, are dependent on two variables' deviation and whether they deviate in the same manner (De Veaux et al., 2009; Field, 2009; Mertler and Vannatta, 2005). Changes in one variable change another. An average sum of combined deviations in order to standardize is called covariance (Field, 2009; Mertler and Vannatta, 2005). By looking at the deviation it can be noticed whether two variables are positively related, not related at all, or negatively related. The Pearson correlation coefficient is a standardization of the covariance of variables measured and this value will be between positive and negative one (Field, 2009). Positive values mean that as one variable increases so does the other and negative values of the Pearson correlation coefficient means that there is an inverse relationship between variables (Field, 2009). Values of plus or minus .1 represent small observed effect, or relationship, plus or minus .3 is a medium strength effect and plus or minus .5 is a large observed effect (Field, 2009). These observed effects should be put in context within the research literature (Field, 2009). Pearson correlations were identified from 65 variables against the variable of passenger rail ridership total for each station, for 66 total variables in the model, using a collection of 91 station areas in Los Angeles.

3.2.3.2 Multivariate Linear Regression Analysis

After finding station area attributes that had positive or negative relationships with passenger rail ridership in Los Angeles, a multiple variable linear regression was performed in SPSS to find the weight or power that these variable have on the outcome of ridership. Multiple regression goes a step further than just looking at similar behaviour of variables and shows the power of one variable on another (Field, 2009). This is also called the prediction one variable can have on another. In the case of multiple regression, several predictors are identified for an effect on an outcome. With multiple regression, the larger the data set the better the model (Field, 2009).

There were several tests done in SPSS on the correlating variables including identifying Pearson correlations close to one between two variables, checking the variance inflation factor (VIF), to be sure it was lower than 10 and the tolerance statistic in below .1 (Field, 2009). This was done to exclude variables that had collinearity and would obscure relationships within the model.

Thirteen discrete variables correlating with the dependent variable passenger rail ridership were included in the next phase of analysis, univariate linear regression. Analysis and identification of unusual cases were performed by viewing the regression line of a first multiple regression including all 91 passenger rail station areas in Los Angeles. Analysis to identify outlier or unusual passenger rail stations including using the Cook's distance and Mahalanobois distances revealed eight passenger rail station cases that were beneficial to remove for greater accuracy. After these steps to increase accuracy a multivariate linear regression was performed through SPSS on 13 discrete variables tested against passenger rail ridership with 83 station cases. This analysis estimates, or explains, the effect of 13 built environment variables on passenger rail ridership.

3.2.3.3 Univariate Linear Regression Analysis

An individual variable regression was performed after viewing the multiple regression results to find the individual contribution that a predictor variable had on the outcome of ridership. The individual contribution is complicated because a predictor variables effect on an outcome is larger when combined with other variables (Field, 2009). Individual regressions put variables, and their predictive power over passenger rail ridership, in a hierarchy. The 13 identified correlating variables were tested with a univariate linear regression in SPSS and the part correlation was squared to find the percentage of singular impact that each of these variables had on passenger rail ridership in Los Angeles.

This three-tier statistical study was useful to eliminate and pare down predictor variables on the outcome of ridership. First, with correlations, significant relationships were determined, then with a multiple regression, a model of prediction was developed from the key correlating variables and then finally, a single regression was used to find which were the most significant single variables in the outcome of ridership.

3.2.4 Place Site Analysis

Two of the most prominent progenitors of modern urban ethnographic study of places, Jane Jacobs and William H. Whyte have made broad connections between the physical form of cities and social life, or behaviour in cities through direct observation and site analysis (Jacobs, 1961; Whyte, 1980). Mathematician and architecture scholar, Christopher Alexander has attempted to reverse engineer forms in nature for the discovery of universal forms for application in design (Alexander 2002, 2004, 2012). While most of these scholars attempt systematisation, Whyte's recorded observation and public place survey methods have inspired current practitioners including Project for Public Spaces, promoted real zoning change in New York City public spaces and was the starting point for the place site analysis presented later in this thesis (Carmona, 2010).

Whyte's research on social life in public spaces involved design and environmental aspects including, plazas as the settings for activities, sitting space design and dimensions, how people congregate and in what mixtures of genders, number and size of street trees, available sunlight, and food vendors amongst other aspects of urban design and plaza use (Whyte, 1980). Other field defining sociologists include the Lynds that ethnographically studied small town urban centres but Whyte combined sociology and design while publishing the steps of how to repeat his study (Lynd and Lynd, 1929; Whyte, 1980).

These attempts to systematize the observation, analysis and the design of public spaces involve common broad attitudes including, the physical place, people, settings and activities as well as other considerations such as scale or economic processes. This ontological or physical approach to behaviour in cities is something of interest to explore in regards to transport and place (Boarnet and Crane, 2001).

Recent advances in data collection including smart cards, or tap cards used for entry and exit of public transport, as well as advances in surveillance and census data offer new opportunities for data driven design to cater to the user experience while increasing efficiency and fare returns (Oliveros and Nagel, 2016; Wang et al., 2015).

A combination of the historical urban observation of Whyte, Jacobs and Gehl now can be combined with statistics to provide guidance for projects that aim to create pedestrian friendly environments and well trafficked environments locations (Ewing et al., 2015). Streetscape elements such as trees, benches and sidewalk attributes can be input against traffic amounts, or use, to find relationships through statistical tests (Ewing et al., 2015).

Thirty-two passenger rail station areas in Los Angeles County were selected to be studied through site analysis. A place site analysis tool was developed from reviewing literature and previous site analysis methods including those used in Boarnet and Crane (2010), Carmona et al. (2010) and Whyte (1980). Station areas were surveyed by exiting the station and walking around the station area in at least a .25-mile radius. There has been some criticism of using the typical .25 or .5-mile catchment areas, commonly used in transport research, namely that they are not oriented from the pedestrian, or users, experience and that these specific distances don’t necessarily have significant perceived value (Guerra et al., 2012). However, they do offer a starting point for standardization. Station site surveys were performed between August 9th and September 12th in 2013.

There has been a recent revival of interest in pedestrian access and friendliness in urban centres, especially how they relate to public transport and public health as well as intercity and international comparisons (Ewing et al., 2015; Frank et al., 2015). The place site visit analysis used in this thesis was modelled on William H. Whyte’s classic study of public places and more recent audits of streetscape elements and pedestrian environment (Ewing, et al., 2016; Frank et al., 2015; Whyte, 1980, 1988). A survey and metric was developed from and predominantly informed by William H. Whyte's system used in The Social Life of Small Urban Spaces with input from similar survey tools used by Jan Gehl, Project for Public Spaces and the priorities of the New Urbanists (Carmona et al., 2010; Gehl Institute, n.d.; Gehl and Koch, 2011; Whyte, 1980, 1988).

The categories of the place and urban design survey include pedestrian access and travel, environment and comfort, social aspects, surroundings and land use, interaction of modes, the built environment and an overall rating with space for additional analysis and comments.

This collection of stations were generally chosen by picking the highest passenger rail ridership stations of each line with supplements, such as Compton station, being included for diversity and novelty for a sample that represents the varied conditions of the LA Metro system. Dates and temperatures of site visits are detailed in Appendix B. The site survey checklist sheet can be found in Appendix B. This survey was used in the place analysis of Berlin, Hong Kong, London, Los Angeles and Medellin.

Table 1. The place passenger rail station site analysis survey.

PLACE AND PUBLIC TRANSPORT SURVEY	**1 or 0**
Pedestrian Access and Travel Category	
Sidewalks and paths are smooth, continuous and well connected to other paths	
Easy for older people, disabled, children and unskilled to walk	
Intersections are easy to cross	
Limited grade changes or hills	
Paths are direct and there are no barriers	
Ground surface quality is good or smooth	
Crosswalks are well timed for foot traffic	
Environment and Comfort Category	
Visible public space	
Plantings and trees	
There is adequate shade	
Good air quality and ventilation	
Open and green space is not a strip or merely decorative	
Adequate sunlight	

Places of shelter	
Visible access to water	
Grass is available	
Environment is not too loud	
Air quality is not bad	
Social Aspects Category	
People on the street	
Undesirable people are not present	
Feels safe	
Surroundings and Land Use Category	
Food and snacks are nearby the station	
Street level retail	
Well-lit surroundings	
Pleasant waiting space	
Interesting urban realm	
Office space nearby	
Significant residential	
Interaction of Modes Category	
Modes interact and cooperate well	
Connecting mode stops are visible	
Transferring seems safe	
Connecting stops are convenient	
Built Environment Category	
Seating	
Public phones	
Roads are well proportioned to sidewalks	
Adequate signage	
Clear view of surroundings	
No blank walls or gloomy environment	
Clean and well maintained	
Human scale or lack of mega structures	
Overall Impression - Choose One	
I want to stay here (4 points)	
It is pretty good (3 points)	
Useful (2 points)	
Difficult to use (1 points)	
Depressing (0 point)	
Total of 44	
Other Comments and Analysis Notes:	

These survey answers were then quantified by counting a yes answer for an amenity as one point and a no answer as zero points. This was a way to make the site visits standardized and to quantify the qualitative. Finally, an overall ranking section was useful in describing stations that may be sufficient in most areas or check all the boxes yet were otherwise outstanding or miserable. There was a large outside section for other comments and analysis that were especially useful for keeping track of qualitative data that was not predicted for in the checklist or to describe aspects within the station area, while covered by the checklist, might need further explanation. These were all added together for an overall score and then put against the ridership numbers of the station obtained from the transport authority. Results from qualitative findings can be, and have been, quantified in this way by counting occurrences or weighting the answers of experts in order to add rigour or standardisation (Bakogiannis, 2014).

Experiential methods or action research has been used to identify user level impacts or pedestrian level factors ignored by typical transport statistical studies (Lucas, 2013). The activity level decisions of users need to be explored for successful public transport systems (Mars et al., 2016). These forms of research have a long history in the social sciences yet, they have been overlooked in transport research (Lucas, 2013). Action research including covering public transport use investigates the more detailed processes of the actual transport use and the barriers to travel behaviour change (Lucas, 2013).

3.2.5 Passenger Rail by Place Analysis

The next steps in the analysis put passenger rail ridership numbers in perspective with the place site survey analysis. The place site analysis survey results are compared geographically with the station passenger rail ridership results. The categories of the place survey are also individually plotted against ridership for more detailed plots of quality by passenger rail ridership. Seven case studies are discussed throughout this section for greater context. These stations presented are a diverse sample of high ridership stations, novel typological cases and very low place survey quality. The included case study stations are 7th Street, Union Station, Compton, Hollywood and Highland, Hollywood and Vine, Willowbrook Rosa Parks and Harbor Freeway. These stations represent a mixture of typologies.

3.2.6 Typology

The final part of the Los Angeles case is an investigation of typologies by examining the Los Angeles case. The types this thesis is concerned with are types of places and types of passenger rail stations and especially how types of each affect passenger rail use. Types of passenger rail stations explored in this thesis include, those with simple boarding platforms at street level, elevated boarding overhead of street level and underground stations below the surface level. Places, or station location is examined in more detail in the Los Angeles case statistical analysis with density, demographics and station character in a way that is more of a taxonomy or scale from numerical data. A systematic analysis of land use by ridership is presented followed by an examination of outliers, or unusual stations in Los Angeles.

3.3 Berlin

3.3.1 Data Collection

Passenger rail ridership data was obtained from the Verkehrsverbund Berlin-Brandenburg (VBB) for the year 2007 for 173 stations. It was not possible to obtain more recent data or data for more stations. I was not able to determine how they arrived at their estimates, through sensors or estimates from samples. I presume they used samples, or some combination of samples and data, because many stations did not have turn styles.

3.3.2 Background Diagnosis

Literature review and site exploration make up the bulk of the background or context information for the Berlin case.

3.3.3 Place Site Analysis

I gathered the place site surveys of station context from a mixture of central Berlin areas, both S-Bahn and U-Bahn for a diverse sample. The 18 station areas analysed in

Berlin made for a diverse mix of station types and context areas for inclusion in this thesis. Stations were surveyed between February 22nd and 26th in 2014. Dates of surveys are detailed in Appendix B.

3.3.4 Passenger Rail Ridership by Place Analysis

Place and passenger rail ridership were compared geographically similar to the Los Angeles case method.

3.3.5 Case Studies

Three place case studies are presented to explain the station context of the passenger rail ridership numbers, Oranienburger Tor, Wittenbergplatz, and Weinmeisterstraße. Five case studies describe the station environments of the higher passenger rail ridership stations, Alexanderplatz, Friedrichstraße, Zoologischer Garten, Potsdamer Platz and Wittenbergplatz.

3.4 Hong Kong

3.4.1 Data Collection

My research visit was hosted by the Department of Social Work and Social Administration at the University of Hong Kong between the 14th and 23rd of April 2014. The Hong Kong MTR allowed me passenger rail trip data for fifteen stations and the data was based on average daily patronage for 2013 at each station. I used the weekday data from Octopus Card, a transit pass, for the majority of the analysis of Hong Kong stations.

3.4.2 Background Diagnosis

Context information for the Hong Kong case includes academic literature and planning document review, two interviews and experiential site analysis of the MTR system. The first interview was with an associate professor at the University of Hong Kong on April 14th, 2014 and lasted one hour. The second interview took place at MTR headquarters on April 17th, 2014 with the Head of Town Planning for the MTR Corporation.

3.4.3 Place Site Analysis

Site analysis was performed during a research visit between the 14th and 23rd of April 2014 on 15 stations of the MTR. Stations of different typologies on both the mainland and the island were surveyed for a diverse selection.

3.4.4 Passenger Rail Ridership by Place Analysis

The geographic comparison of place survey results with passenger rail ridership results were mapped and presented in a graphic manner.

3.4.5 Case Studies

Five case studies describe the place issues in Hong Kong including, Kowloon Bay, University, Admiralty, Tai Koo and Tseung Kwan O. Five cases show the high passenger rail conditions in Hong Kong, including Tsim Sha Tsui, Causeway Bay, Mong Kok, Kowloon Bay and Central stations.

3.5 London

3.5.1 Data Collection

Relevant workshops, seminars and interviews were done over time in London as I was living there for most of 2012 to 2015 and three months of 2016. Field-work was done on the Overground line and the Dockland's Light Railway (DLR). The Overground and DLR overlaps with the other lines, such as the Underground and regional rail, as well as each other. In these cases, the survey of the urban environments lends insight into those lines as well. Ridership data was from 2013 and obtained from the Oyster card data via Transport for London. Site analysis surveys were done in the spring of 2014 between the 18th and 26th of March.

3.5.2 Background Diagnosis

Background information regarding the London case comes from literature review and to a lesser extent various seminars and workshops.

3.5.3 Place Site Analysis

Twenty stations focusing on the London Overground and Dockland's Railway (DLR) were surveyed in the spring of 2014 between the 18th of March and the 26th of March. The Overground and DLR were chosen because they were more similar to the systems in Los Angeles. The sample of these stations were chosen by a combination of ridership performance and station novelty.

3.5.4 Passenger Rail Ridership by Place Analysis

Passenger rail ridership of London stations are mapped and compared graphically with place survey results.

3.5.5 Case Studies

Place case studies presented include Canada Water, Shoreditch High Street, Cutty Stark, Greenwich. Passenger rail ridership case studies included in the thesis through photos and discussion are Canada Water, Highbury and Islington, Stratford station, Clapham Junction, Whitechapel, Bank, Heron Quays, Shadwell stations.

3.6 Medellin

3.6.1 Data Collection

The entire passenger rail system was surveyed and compared with passenger rail ridership from fieldwork was conducted in Medellin in the spring of 2013 and summer of 2014. I received ridership data for 2013 by contacting the Metro de Medellin, which is acquired through turn style reports. At the time the system had 27 stations.

3.6.2 Background Diagnosis

Background information for the Medellin case comes from literature review. Additional background information was garnered from the Development Planning Unit, University College London's (UCL) Growth in Transit summer workshop in 2013. This workshop included field trips and seminars with stakeholders and experts in public transport and urban regeneration in Medellin. I returned in 2014 for the World Urban Forum conference and a Development Planning Unit workshop as well as further site analysis.

3.6.3 Place Site Analysis

The place site analysis surveys were completed between the 4th of April and 9th of April in 2014. The specific dates for the Medellin and four other city cases place surveys can be seen in Appendix B.

3.6.4 Passenger Rail Ridership by Place Analysis

Passenger rail ridership of the Medellin stations for Linea A and Linea B are compared graphically with the place site analysis results.

3.6.5 Case Studies

Ten cases are introduced through street level images and discussion to explain the condition of place quality and passenger rail ridership context in Medellin. These cases studies include Niquia, Poblado, Envigado, Itagui, Parque Berrio, San Javier, Floresta, Universidad, Santa Lucia and San Antonio.

3.7 Triangulation and Comparisons

The final analysis chapter includes efforts to condense or assimilate these different forms of data collection and analysis across the five case study cities through a triangulated approach. Triangulation combines three methods to create a more credible and valid result than any of the methods could produce on their own, for a more holistic approach and understanding (Groat and Wang, 2002; Minoura, 2016). Triangulation in this thesis looks at the combination of background data, statistical data and site analysis data. The chapter begins with a background comparison of average passenger rail ridership numbers and place site analysis survey result by city. A bivariate Pearson correlation was performed on each city individually, Berlin, Hong Kong, London and Medellin using context variables discovered through mapping and site analysis and was analysed by passenger rail ridership. All cities, including Los

Angeles were then put through a bivariate Pearson correlation separately to find correlations between place attributes and passenger rail ridership. Finally, a multiple, or multivariate, regression was performed for all these cities together to discover the impact, or weight, of identified predictor variables on passenger rail ridership.

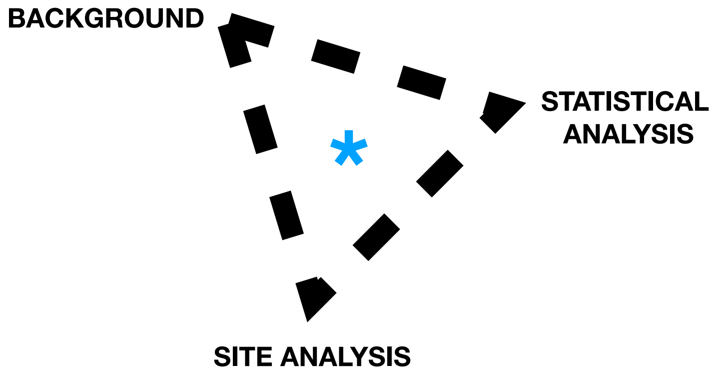

Figure 6. Three methods of data collection and analysis combine to be greater than their individual offerings and provide more data than any one method alone (adapted from Minoura, 2016, p.78, after Groat and Wang, 2002).

3.8 Limitations

The three main categories of research used for this thesis each have limitations in the information they may provide. The triangulation of mixed-methods, and the use of comparative cases, reduces the limitation of any one method and provides a more holistic understanding of processes and conditions (Yin and Campbell, 2018). This triangulation across five cities develops a consistency of research methods and data for comparison. Lack of consistency of methods from place to place has hindered the comparative transport research (Frank et al., 2016). Case studies and transport research have often focused on central areas rather than low or middle-income areas despite low-income areas having the largest populations (Brand, 2013; Brand and Davila, 2013; Frank et al., 2016). This thesis provides analysis from five international cases as well as large diverse areas of study within those cities for robust conclusions on transport through three main categories of methods, background analysis, statistical analysis and place site analysis. The limits of each method is discussed in the following.

3.8.1 Background Analysis

Background research including interviews, literature review and text analysis provide a frame for viewing urban processes. Advantages of interviews is that the information transfer is immediate and bountiful (Yin and Campbell, 2018). Interviews also allow for discussions and questions, especially in terms of new ideas or events that have not yet been published (Yin and Campbell, 2018). Interviews are also flexible and can be adapted mid-interview (Yin and Campbell, 2018). However, interviews and these background qualitative methods in general, are labour intensive and require a heavy time cost (Yin and Campbell, 2018). Human bias is also a drawback of incorporating interviews into research. It is possible that the interviewer could affect the interview conversation. Professionals may be also be intimidated by an interviewer or nervous during an interview. The semi-structured interviews were the start of field-work and were for the purposes of data gathering.

Literature or policy review may reflect others' opinions or an outdated reality because publication takes time. Text or content analysis has been criticized because conclusions or inferences may be drawn too easily from the number of occurrences in a text or interview (Geneletti and Zardo, 2016; Woodruff and BenDor, 2016). There is a danger of reducing text to quantities because that reduces complexity. Background analysis is limited by the fact that it does not monitor change. However, understanding the theoretical, political or physical context is necessary and provides a much greater understanding of that change being studied. The text analysis of city planning plans and policy documents was used in this thesis to compliment and substantiate insights from the interviews. The background, or context, research of this thesis is combined with statistical analysis to provide a more holistic picture of passenger rail station use.

3.8.2 Statistical Analysis

Criticisms of statistical analysis involve the failure to consider qualitative aspects (Field, 2009). Statistical analysis does not deal with individual cases and usually requires a collection of normal or like cases to be analysed (Field, 2009). Often in urban planning we want to study outliers, cases that are novel or catalytic cases that resist trends. Statistics only explains what is input into the model and makes approximations off of average or normal cases (Field, 2009). Data sources compiled by others in statistical analysis, may be compiled by those that have their own biases or different research goals. In this thesis United States census data failed to provide built environment elements or urban quality characteristics. The use of statistics and geographic information systems in architecture and urban design has lagged behind the fields of social sciences and marketing (Minoura, 2016). Furthermore, results of statistical analysis without a qualitative context or frame, may results in the misuse or misunderstanding of those conclusions. Numerical conclusions may occlude complex processes. In general, statistics only tells part of the story, especially when it comes to human behaviour. However, statistical models are useful for presenting trends and providing rigour to qualitative research (Field, 2009).

3.8.3 Place Site Analysis

Mapping through satellite images, or other software including geographic information systems has some similar drawbacks to using data sources compiled by others. For example, several military or government structures were not visible on Google Maps in Los Angeles yet they were a part of the built environment near transport stations and impacted the use of the area. There must be balance between digital sources and real life site analysis.

The place site analysis introduced in this thesis was costly in terms of labour, time and funding. However the site analysis was the most effective when considering physical factors such as the built environment and presence of urban design elements missing from census data. Similar to interviews as a method, there is an immediacy of results when performing site analysis. Site analysis is less effective when researching social or economic factors yet new data sources such as smart cards or geographic information systems software are increasing ways to incorporate the social and economic factors of populations with mapping and site analysis. When studying pedestrian experience and issues that affect their use of space, it is important to use methods at the same scale of experience (Frank et al., 2015).

However, site analysis is complex and depends on the social and physical position of the investigator. My role in the site analysis of station areas around passenger rail was of an experienced public transport user. For the most part I researched places I knew well or had been before, except for Medellin. I had been to Berlin twice for short visits previous to site analysis. I lived and worked in transport in Los Angeles for approximately eight years, which is one reason for the more detailed case study. I have also lived and worked in urban design in Hong Kong for approximately one year and know the areas well. I lived and studied in London, predominantly for this thesis for approximately four years.

Some aspects of passenger rail stations were excluded because I was working off of prior site analysis models that looked at plaza or public space (Ewing, et al., 2016; Frank et al., 2015; Whyte, 1980, 1988). Certain aspects of the interior of the station including lifts, or elevators, were not recognized in the place analysis because they had not been incorporated in previous place analysis models that guided this study. Furthermore, this study focuses on the interaction between passenger rail stations with their neighbourhood not the interior amenities of the station (Ewing, et al., 2016; Frank et al., 2015; Whyte, 1980, 1988). However, we know that attributes such as elevators or escalators can play a part in the choice of transport station, especially for the aged, those with children, those that are differently abled, or those that have baggage. Incorporating these elements into future studies would be interesting. Also, the Los Angeles case was the first case studied and elevators, or lifts, as well as other accessible compensations for differently abled people are present at every station. Los Angeles as the first case set up the study for the other city case studies informed the creation of the site analysis, and Berlin, Hong Kong, London and Medellin. While some aspects of the site analysis are qualitative or based on this researchers opinion, such as feelings of safety, the place site analysis developed for this thesis has largely held up in comparison to other metrics including the Grading California's Rail Transit Station Areas (GCRTSA) by the University of California at Berkeley (UC Berkeley) Center for Law, Energy and the Environment (CLEE) (Elkind et al., 2015) .

Depicting the place environment through photography was also complicated. Photos like statistics tend to override other more layered or qualitative forms of research. The photos used for the site analysis case studies in this thesis are a combination of personal photos and the Google Street View via Google Earth and Google Maps (after Nicholaou, n.d. from Google Earth, 2017). This combination was used depending on which photo was available for most clearly describing the place environment. Google Street View has a more panoramic view and is sometimes more clear than a photo by a pedestrian that might be disadvantaged by vantage point or perspective. In some site analysis cases it was preferable not to take photos because of crowds, possibility of theft or unwanted attention. Another advantage of Google is that their images have the faces of people in them already blurred out. Faces in photos must be unrecognizable I have pixelated faces in personal photos. I contacted the UCL Copyright Support Officer and was informed that Google is generous with their image use, including annotating their maps, as long as they are properly attributed.

One of the main challenges of doing site analysis research is that the built environment does change, sometimes rather quickly. Since site analysis in 2013 and 2014 new passenger rail lines have been added and extended in Hong Kong, station areas remodelled in Los Angeles and rail lines extended, new rail lines opened in London and a multitude of station repairs, damages, nearby business turnover and development across the five cities. While site analysis offers only a moment of the behaviour of passenger rail stations and associated public life, site analysis does offer insights into the pedestrian level realities, often absent from other research methods including statistical analysis.

3.9 Position of the Researcher

The position or appearance of myself being an able bodied large male, and an experienced transport user affected my access of the passenger rail station areas because it is easier for me to physically and safely navigate space than others. Beyond that it is unclear to me how my personal identity affected the site analysis because the case studies covered broad socio-economic and political geographies. Aspects of race, size, sexuality or gender possibly affected my use and research of space especially when considering if public spaces felt safe, for example. Stations in London and Medellin required traversing several flights of stairs at a time and crossing long pedestrian overpasses that would have been difficult if not impossible for some people. I tried to keep this in mind when filling out the site analysis, that if conditions required effort for myself they were probably problematic for others and possibly affected their station choice. Stations that were under construction, with usually accessible routes constricted, made navigation of passenger rail stations even more complex in all five cities studied. As an educated and professional researcher I felt I had a right to be in these public places, while some people from different backgrounds would not feel as comfortable auditing or loitering in these spaces. I also knew many of these station areas well, and had a minor to moderate working knowledge of Spanish, German and a little Cantonese.

3.10 Ethics and Risks

Prior to field-work, department and UCL approved code of practices were followed in regards to ethics, travel insurance and risk assessments. These processes included application to the UCL Research Ethics Committee, risk assessments of field work, obtaining UCL travel insurance and following data protection guidance. Some of these layers of risk assessment were required by the Bartlett School of Planning and other clearance components were additionally required for funding by UCL and Yale University. The study of this thesis does not include human participants or experiments on human subjects, therefore most of the risks were in regards to my physical experience. Some stations were under construction, making accidents more probable than clean or well-maintained stations. While most passenger rail stations were places of possible petty theft, some stations and travel in Los Angeles and Medellin had unpredicted risks of more serious threats including violent crime. A city-wide protest occurred during the first field-work visit to Medellin and I was stranded for one day on a university campus. However, no instances of injury or accident occurred during field-work.

4 Los Angeles Background

> Los Angeles was a place where people came to leave behind their old ideas about cities, industries, and culture. This is what allowed it to welcome new industries and make them its own. This is the essence of the creative milieu. (P. Hall, 1998, p.552).

Los Angeles, amongst many other cities, remains a contrast to the processes of a single centre city. Los Angeles has a diverse urban form that is a combination of dispersion and congregation noted by the following figures, Figure 7 and Figure 8, of Los Angeles, that show the economic sub centres and the transport activity maps respectively (Boarnet, Hong and Santiago-Bartolomei, 2017). Cities like Los Angeles are polycentric with many employment centres. Los Angeles is a series of rectilinear grids that developed over time (Boarnet, Hong and Santiago-Bartolomei, 2017; P. Hall, 1966, 1998; P. Hall and Pain, 2006). Separate city centre growth spurts, or leap frog development, are now connected in the present for a large urban polycentric spread (Boarnet, Hong and Santiago-Bartolomei, 2017; Lynch, 1960, 1961).

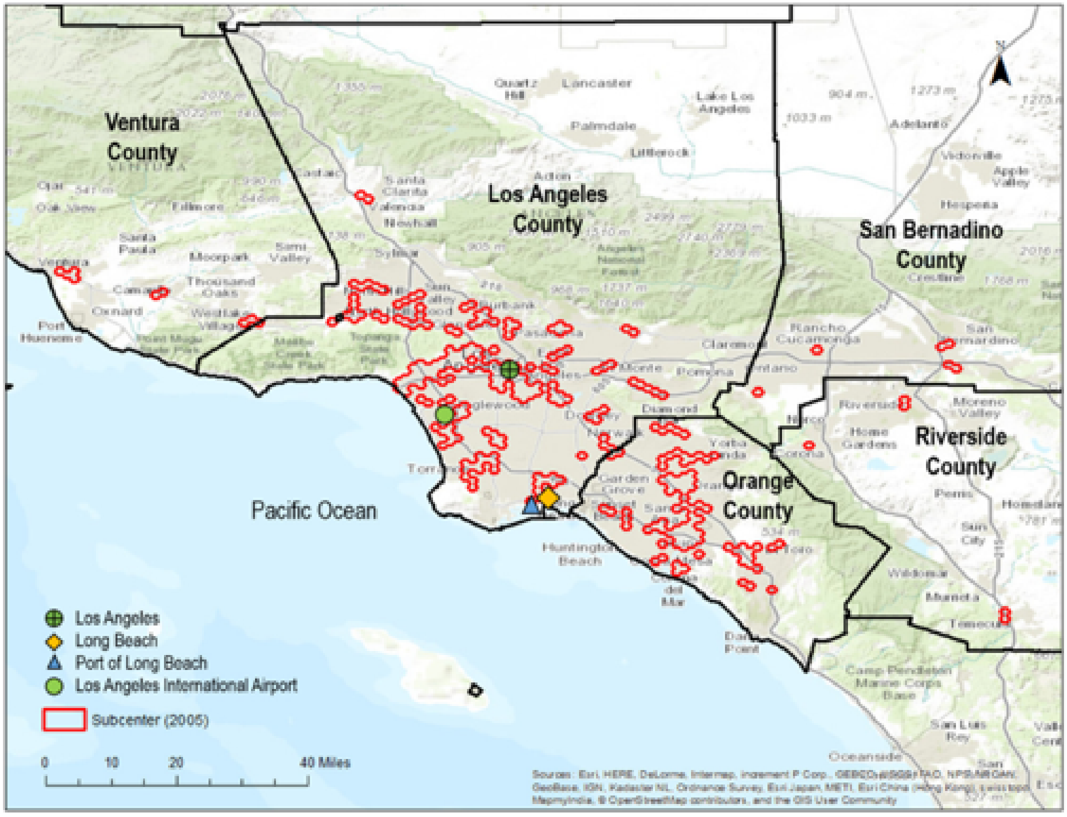

Figure 7. Polycentric arrangement of the employment centres of the Los Angeles region (Boarnet, Hong and Santiago-Bartolomei, p. 270, 2017).

The strategy thus far of the Los Angeles County Metropolitan Transportation Authority has been to initiate public transport in the downtown historic core with long commuter legs reaching out to the suburbs. However, evidence has shown that transport ridership and return of environmental and economic benefits are dependent on the size, complexity and overlap of public transport (Cervero and Guerra, 2011; Guerra and Cervero, 2011). New systems, like Los Angeles', will also have increasing benefits of fare recovery and time-savings as the system expands (Cervero and Guerra, 2011; Grube-Cavers and Patterson, 2015). Los Angeles' system itself is still in an initial phase of investment but will begin to mimic the fare recovery rates of other large dense American cities (Cervero and Guerra, 2011). A threshold of accessibility before transport investments become profitable, along with increased ridership, is nascent in burgeoning transport systems (Cervero and Guerra, 2011). Neither the costs nor the benefits of public transport are linear, with intense upfront investment being necessary.

The flexibility of the car has been fundamental to the development of Los Angeles and its urban processes. However, auto transport networks have been compromised as congestion has increased to the point where travel times via the freeways is excessive and costly. This has motivated a transport upheaval by the city and planners of Los Angeles, resulting in new transport systems. Los Angeles differs from many cities because its downtown is not at the centre of a radial plan. Los Angeles remains a contrast to the processes of a single centre city. Figure 8 shows a heat map of freight travel in the Los Angeles region, a major component of auto travel in Los Angeles and an indicator of auto travel in general. The Los Angeles passenger rail system is an attempt to stretch out to connect to the many sub centres of the Los Angeles area.

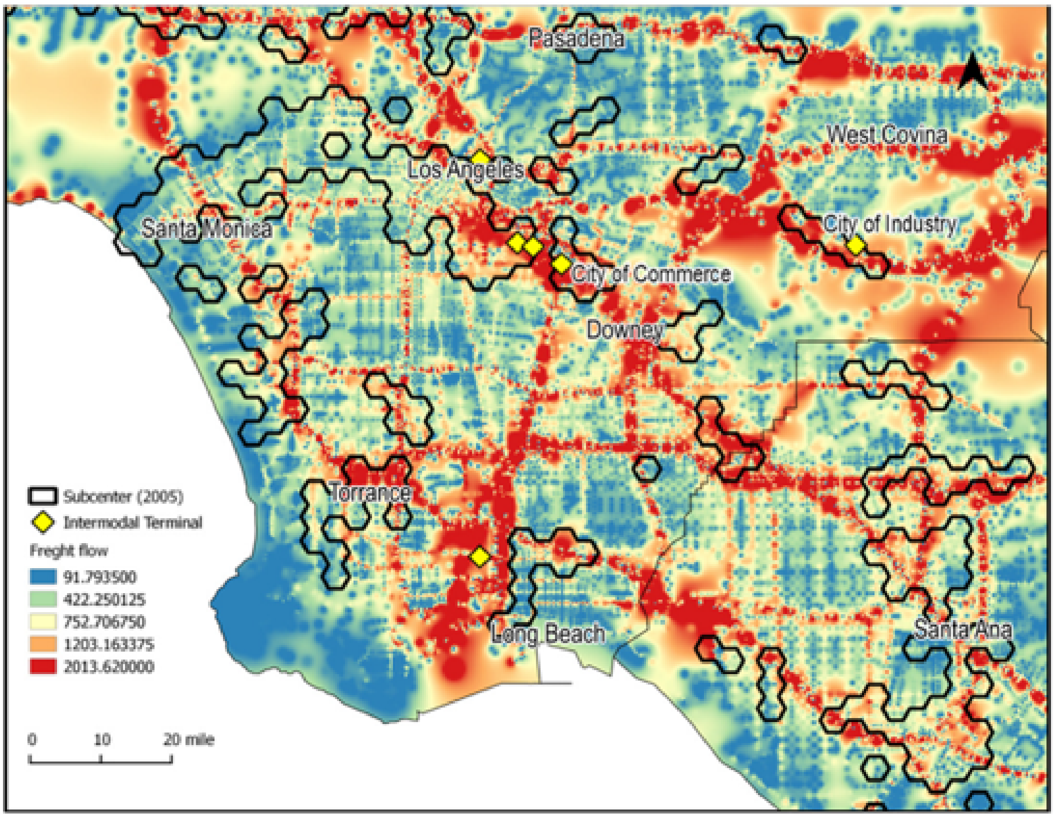

Figure 8. Freight congestion, all trucks, in Los Angeles region showing a polycentric pattern (Boarnet, Hong and Santiago-Bartolomei, p. 275, 2017).

The expansion of streetcar systems is ironically credited with some of the urban spread in Los Angeles (P. Hall, 1966). Los Angeles' streetcar system was especially extensive and allowed a sprawling linear development (P. Hall, 1966). The successors of the streetcar, the large bus system in Los Angeles and the popular private automobile allowed this stretching development to fill in after 1920 (P. Hall, 1966). Contemporary Los Angeles is a series of rectilinear grids that interchange and sometimes overlap with diagonal streets (P. Hall, 1966). Polycentric evolution is not confined to Los Angeles and the single centre city has been called an anachronism (Ewing, 1997). While densification and transit-oriented development has been largely promoted in literature, the materialization of these policies remains a challenge and source of study.

Urban passenger rail returned to Los Angeles in 1990 and now consists of two rapid subway lines, four light rail lines, two bus rapid transit lines and connects to other regional rail systems such as Amtrak and Metrolink commuter rail system along with the extensive bus system. Amtrack is long distance and separate from the LA County lines. Metrolink was introduced after 1990 as well and is a greater suburban system that connects through Los Angeles at the downtown Union Station. Metrolink is a commuter rail system of seven lines. Trains from the outer cities and outside Los Angeles County deposit commuters at Union Station, connect to the urban LA Metro system. California Amtrak runs long distance intercity trains throughout California and connecting to the national Amtrak system that reaches 48 states of the United States. The Pacific Surfliner along the west coast of Southern California with nearly 3 million passengers per year, is the most used Amtrak corridor outside of the Northeast corridor. Amtrak also connects to Union Station near downtown Los Angeles. At the time of this research, the LA Metro system has 85 discrete stations with plans to double the system due to the recent passage of two sales tax portions dedicated to public transport in the county.

The urban LA Metro passenger rail system that predominantly serves Los Angeles city and is a fixed guide way train system is the main focus of this thesis in the analysis chapters. The LA Metro system does cross into some nearby cities including Pasadena, South Pasadena and unincorporated areas. Passenger rail station architecture for the urban LA Metro passenger rail system is very diverse, even while on the same line, with platforms being at grade, slightly above grade, underground below buildings, underground yet uncovered, and elevated above passing cars or in the middle of freeways with access from the street level.

Los Angeles is currently the second largest city in the United States with a population of 3,900,794, estimated for 2015, and a major centre of world and domestic trade (U.S. Census Bureau, 2015). The city is 503 square miles large with a Mediterranean climate that only has approximately 35 days of precipitation annually (U.S. Census Bureau, 2015). There has been over a 100,000-person growth of the city since the 2010 demographic profile that estimated the population at 3,792,621 persons (U.S. Census Bureau, 2010). The County of Los Angeles, a substantial portion of the five counties that makes up the Greater Los Angeles Metropolitan area is home to 9,818,605 persons (U.S. Census Bureau, 2015). The 4751 square miles of Los Angeles County's geography includes the coast of the Pacific Ocean, forests, deserts, mountains, valleys, islands and lakes (U.S. Census Bureau, 2015). The Los Angeles – Long Beach combined statistical area is estimated at 18,679,763 people for 2015 making it one of the largest urban areas in the world (U.S. Census Bureau, 2015).

However, density is complicated as a measure of Los Angeles because of peaks and valleys and because of urban spread. Different density results occur with different boundary lines. There are about half as many housing units in the city as people yet in the county there are around a third of housing units as there are people (U.S. Census Bureau, 2015).

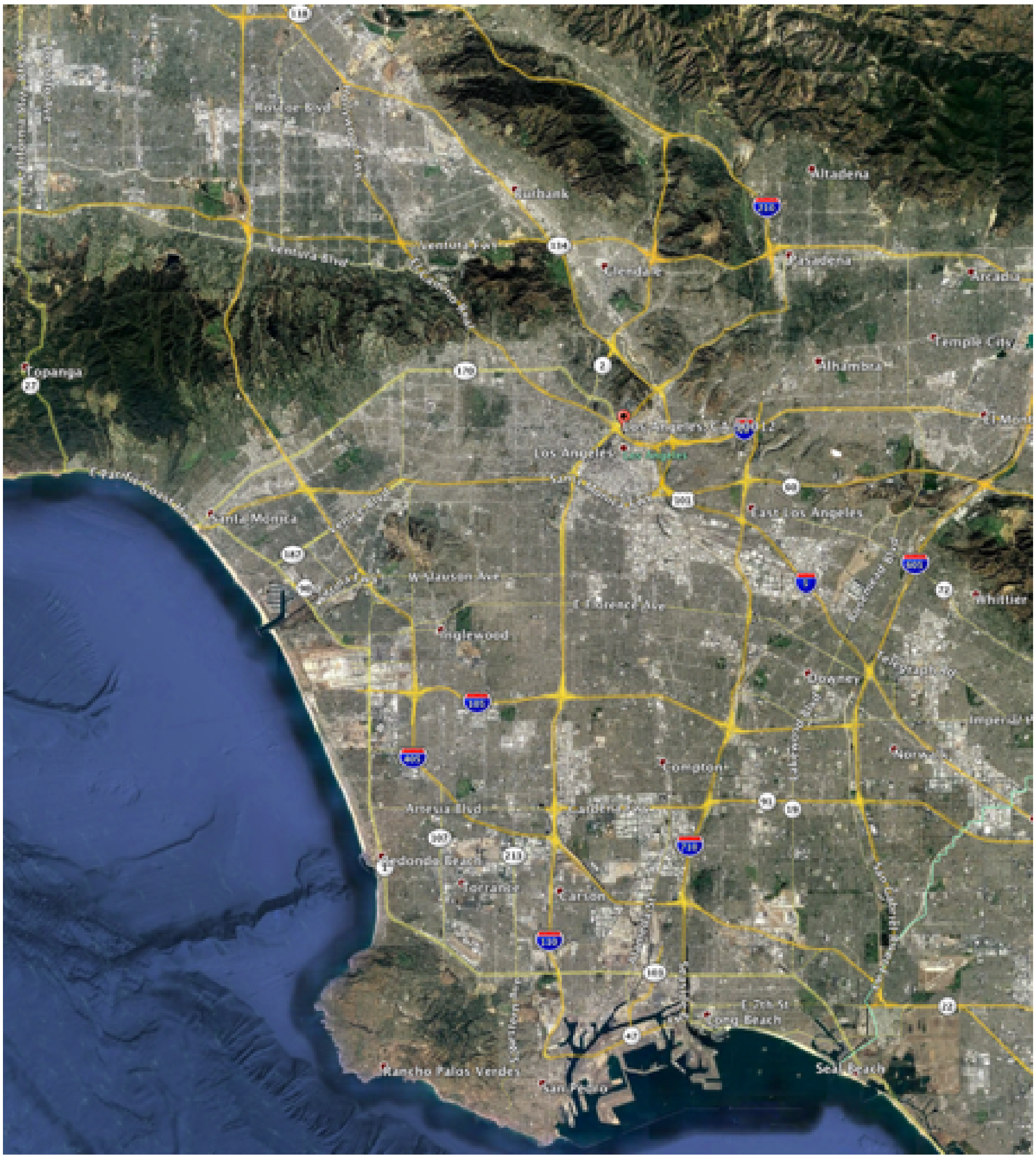

Figure 9. An approximation of Los Angeles city area and the most urbanized areas. The red flag in the centre shows the downtown locus of the rail system (Google Maps, 2018).

The Red Line and Purple Line are underground systems. The Gold Line, Blue Line and Green Line stations are light rail lines that travel at grade with some sunken or overhead conditions. The Exposition (Expo) Line travels predominantly along Exposition Boulevard and also has a varied station condition, starting out underground in central Los Angeles and then travelling at grade for much of its path with some elevated exceptions.

The median age of the city is slightly younger than the county at 34.9 years versus the county's 35.6 years. This is towards the younger side of the working age spectrum and California is trending younger, especially Southern California, in comparison to the Northeast metropolitan areas (U.S. Census Bureau, 2010). The United States' median age was 37.2 (U.S. Census Bureau, 2010). The West in general trends younger than the South, Midwest or Northeast general regions (U.S. Census Bureau, 2010). Los Angeles had the 3rd largest number of new arrivals of any city in the United States between July 2014 and July 2015 with 34,943 new persons (U.S. Census Bureau, 2015).

Los Angeles is one of the most diverse places in the world with approximately 3.5 million of the 10 million large county population being foreign born (U.S. Census Bureau, 2015). The ratio is slightly higher in the city with 1.5 million of the 4 million strong population being foreign born, roughly (U.S. Census Bureau, 2015). In the county, 49% of the population are considered Hispanic while a little over 14% are considered Asian alone (U.S. Census Bureau, 2015). This is roughly analogous to the city's 48% of people being Hispanic and a smaller portion of the urban population being Asian, 11% (U.S. Census Bureau, 2015). African Americans account for more than 8% of both city and county populations (U.S. Census Bureau, 2015).

The economy of Los Angeles City has 496,999 companies, part of the county's 1,146,701 companies (U.S. Census, 2012). 75.5 % of the Los Angeles City population is educated at or beyond a high school graduate level in comparison with the Los Angeles County's 77.3% (U.S. Census Bureau, 2015). Median household income is also slightly higher in the county than in the city at $56,196 versus the urban $50,205 (U.S. Census Bureau, 2015). The largest civilian industries in the city are educational services including health care and social assistance programs, followed by professional services including science, management and waste processing. The third largest industry combines the arts, entertainment and recreation. In both the city and county contexts, government workers make up a small portion of total workers at around 13 to 15%, with the city having the smaller share of government workers

(U.S. Census Bureau, 2015). Manufacturing remains large in the county with 476,733 manufacturing jobs (U.S. Census Bureau, 2015). However, the portion of individuals living below the poverty line is high, possibly due to high real estate prices. In the city, 22% of people live below the poverty level and county locations do not fare much better with 18% of the population living below the poverty line (U.S. Census Bureau, 2015).

4.1 Funding and Policy Context

The region of Southern California is supported by tiers of governance including legislation and funding at the city, county and state levels. An especially relevant organization is the Southern California Association of Governments (SCAG) that includes cooperation from 191 cities and 6 counties (Southern California Association of Governments, 2017). The SCAG develops long-range transportation plans and the sustainable communities plan including growth forecasts, transportation improvements and housing needs. This organization as well as the Los Angeles County Transportation Authority help to knit the large regions of Southern California together. There are many issues that overlap and need to be juggled to proceed and overcome silo planning (Healey, 2007). This is especially important in Los Angeles, where the City of Los Angeles completely surrounds some cities like West Hollywood and Beverly Hills.

Two pieces of significant legislation are the California state assembly bill 32 called the Global Warming Solutions Act and the senate bill 375 from 2009 that regulates Greenhouse gasses from light trucks and cars. Senate Bill 375 requires the California Air Resources Board to develop regional targets for the reduction of Greenhouse gasses from autos and light trucks and regions are tasked with a sustainable communities strategy that combines land use to meet reduction targets (California Air Resources Board, 2014; California Air Resources Board, 2016). The focus of these policies are on vehicle miles travelled and sprawl. Each transportation authority must prepare and adopt a regional plan to achieve a balanced system. Two major environmental protection acts involved in rail construction are the National

Environmental Policy Act (NEPA) of 1970 and the California Environmental Quality Act (CEQA) of 1970 (United States Environmental Protection Agency, 2017; California Natural Resources Board, n.d.a). CEQA and NEPA are further important because they place environmental requirements on the construction process. These are only a few of the most important environmental policies within the California context.

In 2006, the California Global Warming Solutions (California Environmental Protection Agency, 2006.) act set targets for state Greenhouse gas (GHG) reduction from all sources. This act requires the California Air Resources Board, an agency that predates the federal Clean Air Act, to reduce emissions to a 1990 level by 2020 resulting in a 25% reduction (U.S. Environmental Protection Agency, 2012). The California Senate bill 375 (SB 375) of 2008 took a further step by requiring metropolitan planning organizations to develop a Sustainable Communities Strategy to achieve these reduction targets (California Environmental Protection Agency, 2012). SB 375 empowers and requires local planning authorities to develop transportation plans to reduce private vehicle and light truck greenhouse gas (GHG) emissions. Currently, the transport sector accounts for 40% of GHG in California. Private car and light trucks account for 30% of total GHG in the state. They also account for 50% of air pollution, and 70% of the state's petroleum consumption (California Environmental Protection Agency, 2012).

A series of sales taxes in Los Angeles make up the primary funding resources of the LA Metro (LA Metro, 2017b). Proposition A from 1980 provides a 0.5% sales tax (LA Metro, 2017c). Twenty-five percent of this sales tax returns to the cities within the county (LA Metro, 2017c). Proposition C in 1990 provides another half percent of sales tax and returns 20% to the cities (LA Metro, 2017c). However, voters limited Proposition A and C in 1998 for only above ground use (LA Metro, 2017b). Measure R in July of 2009 added a large influx of funding to the LA Metro with another 0.5 % sales tax, of which 35% goes towards new bus and rail lines. The other portions go towards improvements, car pool lanes, bus operations and highway improvements (LA Metro, 2017d). Another sales tax measure passed recently and went into effect in July, 2017 (LA Metro, 2017a). The measure passed with 70% support of the vote, extended Measure R indefinitely and has no expiration itself (LA Metro, 2017a). This measure commits transit fares to remaining affordable with 120 billion dollars estimated revenue over 40 years. In the past the Mayor of Los Angeles was able to leverage Measure R income to attain financing from the Federal Government for front-end funds to acceleration construction. Other funding comes from state and federal sources such as the Transportation Development Act, a portion of gas and diesel taxes, and other sources such as toll road fares and lease revenues (LA Metro, 2017b). The sales tax propositions and measures are important because they flow directly to LA Metro for allocation (LA Metro, 2017b).

Beyond these local funding regimes, there exist state and federal funding for transportation and contingent improvements. Portions of the 18 cents per gallon state gasoline tax and the 18.4 cents per gallon federal gasoline tax are also channelled to local transportation projects. The California Department of Transportation as well as the Federal Highway Administration, Federal Transit Administration all organize funding and management of projects (LA Metro, 2012b). LA Metro states that the total estimate county revenue for transportation from 2012 to 2021 at $US 64 billion. This amount is 67% funded by local sources, 21% funded from state sources, and 12% from federal sources (2012b).

Current LA Metro projects underway are regional connector to connect a gap between the two hubs of Union Station and Downtown Los Angeles that will allow more trains to flow from the suburbs through to Downtown Los Angeles without transfer. The Purple line subway extension is under construction and will extend to the west side of Los Angeles. The Exposition Line has completed its second phase of construction extending from Downtown Los Angeles to the coast of Santa Monica. Other extension projects are in planning and research phase such as connecting from the Green Line to the airport and extending the Gold Line further east. High-speed rail has made some intermittent progress in California and there are plans to capitalise on Los Angeles connections and upgrading as part of the strategy.

4.2 Mapping Lines in Los Angeles for Diagnosis

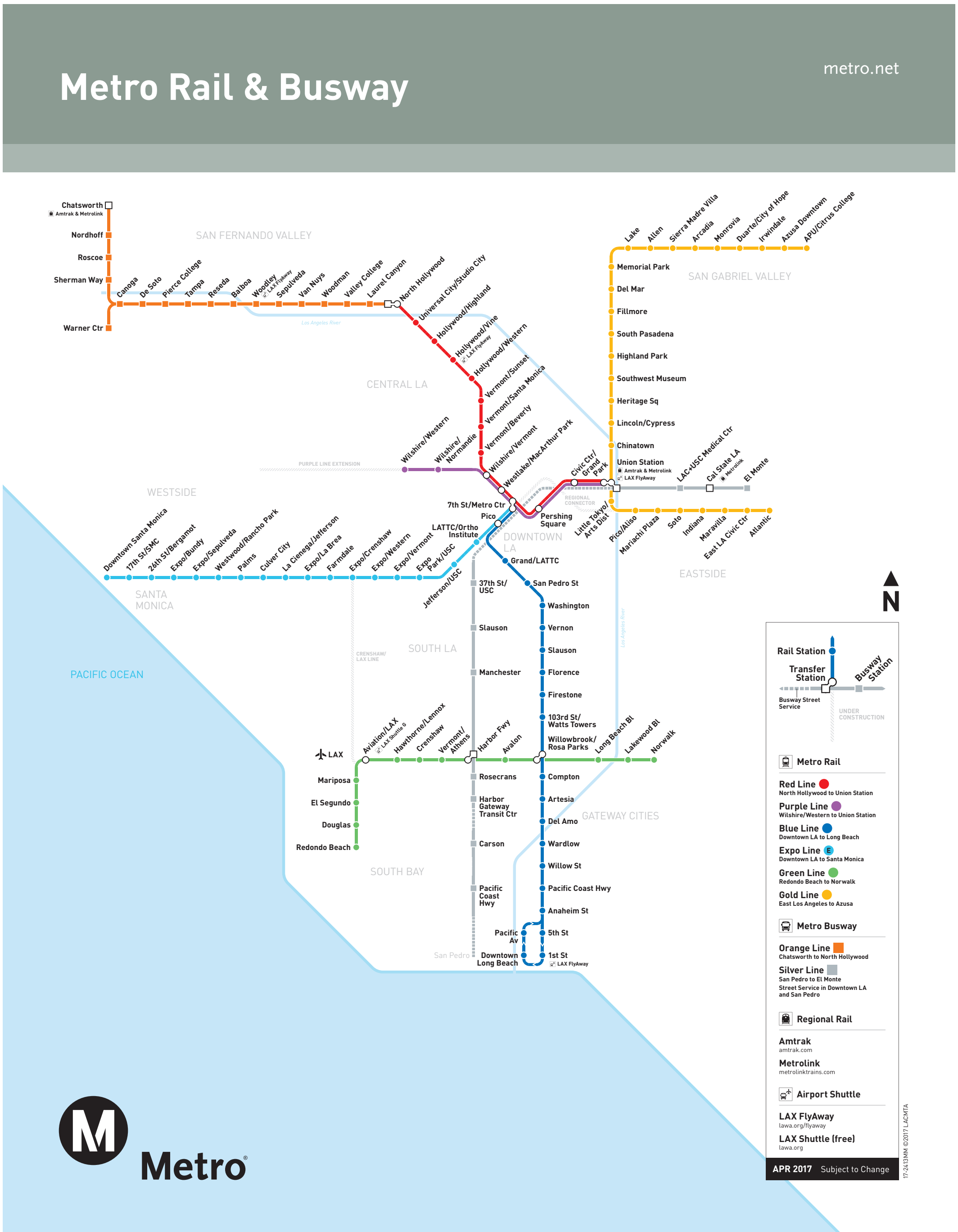

Figure 10. The Los Angeles passenger rail system and two bus rapid transit lines as of June 14, 2018 (LA Metro, 2018).

There are six current passenger rail lines of the LA Metro transit system and two bus rapid transit lines with some interaction from regional rail lines. The Blue Line light rail line opened in 1990 and runs from downtown, through southern Los Angeles to Long Beach. The Blue Line's 22 stations are predominantly at grade through lower income areas and had 29,181,378 boardings in the fiscal year 2013 with approximately 3.5 million more boarding than fiscal year 2011. The Red Line is the second oldest line that began operation in 1993. The Red Line is an underground, heavy rail faster line that has 14 current stations across downtown and Hollywood. The Purple Line, also an underground heavy rail line, was added to part of the path of the Red Line in 2006 and is under construction across Los Angeles to the west. The Red Line and the Purple Line have a combined 49,516,465 total boardings for fiscal year 2013. Three other light rail lines, the Green Line, the Gold Line and the Expo Line opened in 1995, 2003 and 2012 respectively. Their ridership numbers of the Green Line and Gold Line are approximately 13 million trips for the year 2013. The Expo Line had 7.6 million trips for the fiscal year 2013 but the system was new and likely to grow in ridership. The Expo was also opened in two phases, the second of which opened in 2015 also likely grow ridership numbers substantially as it connects more nodes including with the City of Santa Monica, with seven new stations, to central Los Angeles. The Gold line connects the other cities of Pasadena and South Pasadena to Los Angeles and has three transit-oriented developments.

Two other lines in the map are the Orange Line and Silver Line bus rapid transit lines. The Orange Line is a segregated bus rapid transit line that runs through the San Fernando Valley to connect to the Red Line at North Hollywood station. The Orange Line serves at least two community college campuses and returned over 9 million boardings for the fiscal year 2013. The Silver Line has a partial segregated path and winds through downtown Los Angeles. The bus system, including the bus rapid transit lines in Los Angeles and returned 345,565,410 trips in the fiscal year 2013. The data in the preceding paragraphs was obtained directly from Los Angeles Country Metropolitan Transportation Authority.

However, large areas of the City of Los Angeles and the San Fernando Valley were designed for the automobile and traversing space in a private car. New bus and passenger rail lines are set within a context of streets that are still many lanes wide, sometimes with little shade. Blocks and intersections are spread out beyond a pedestrians' comfortable walking distance. A pedestrian connectivity strategy needs to accompany these new stations and routes so that people can walk to and from stations. From this investigation of the transport context of Los Angeles many challenges, including ownership, site geometry and anti-pedestrian factors have been noticed. Many low-density stations could be developed at higher-densities for greater transport use. The diverse ownership of small lots surrounding stations present a challenge for development because the transport agency would have to negotiate with many different owners.

4.2.1 The Gold Line Light Rail and Orange Line Bus Rapid Transit

The Orange Line is a bus rapid transit (BRT) line that begins at the end of the Red Line heavy rail subway system's terminus at North Hollywood. Planned for an eventual upgrade to light rail, this BRT has exceeded ridership predictions and while many other public transport projects are going ahead in the region, the transformation of the Orange Line to light rail has not happened. The Orange Line runs through predominantly residential suburban neighbourhoods with commercial and retail space in the San Fernando Valley, such as Burbank and Woodland Hills. The Bus Rapid Transit has a dedicated lane with landscaping and limited interaction with the auto street grid. For large portions the Orange Line is accompanied by pedestrian and bike paths. Buses have racks for those connecting by bicycle.

The San Fernando Valley is in many ways the stereotypical car-oriented Los Angeles. However, while this is mostly true in regards to mobility, there are still buses throughout, ample retail and commercial space and single-family homes are often on fairly compact parcels.

We can see these opportunities with the BRT stations that are closer to the City of Los Angeles or central urban areas. Older suburbs have smaller lots and closer retail opportunities. Newer suburbs often have curving roads and are gated, or completely segregated from retail. There is an archaeological footprint of the old Los Angeles electric streetcars that could be capitalized on. The more recently built Exposition Line appropriates a right of way that was previously used for the historic streetcars.

Figure 11. The Gold Line stations through East Los Angeles, Downtown Los Angeles, South Pasadena and Pasadena (LA Metro, 2018).

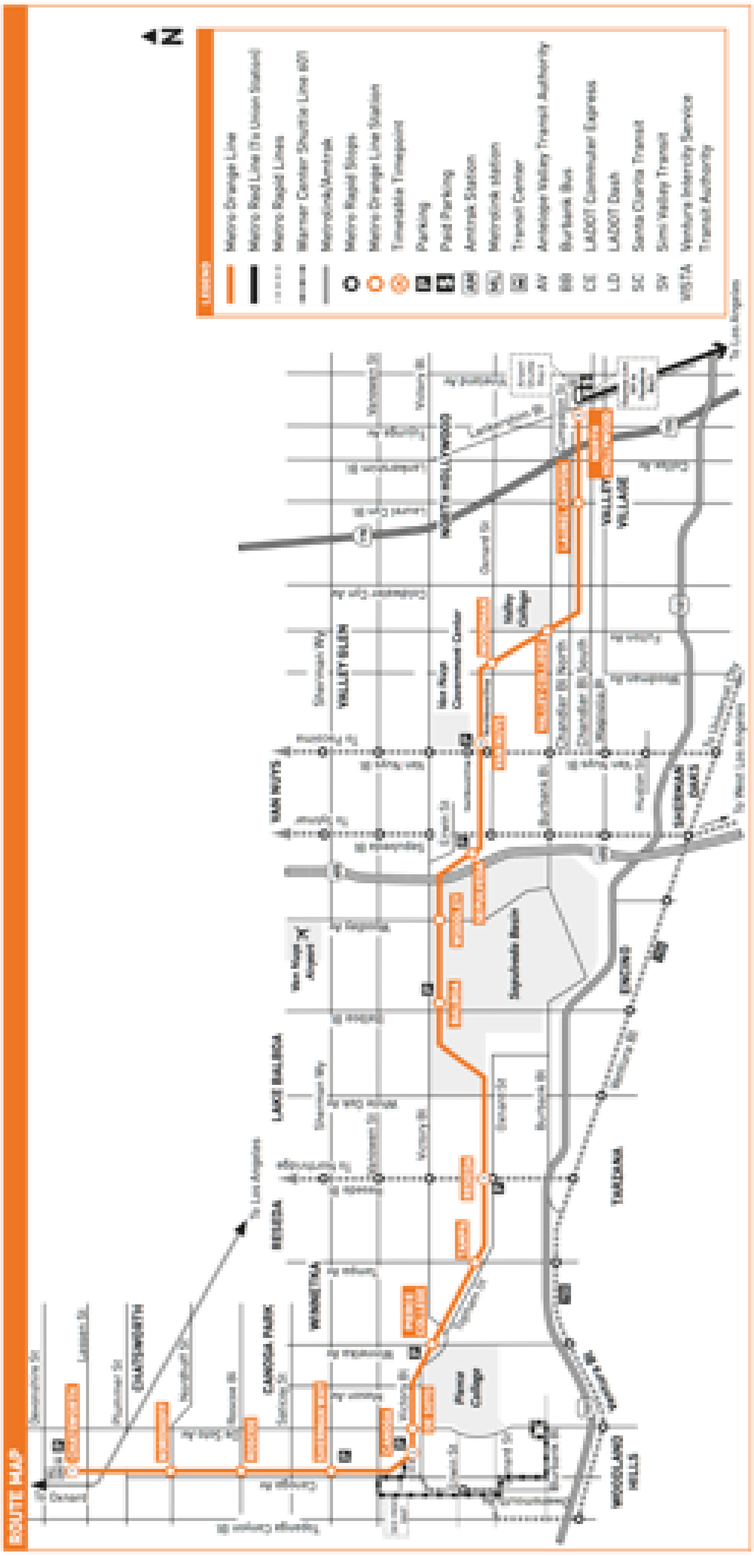

Figure 12. The Orange Line bus rapid transit line as of September 2, 2018 (LA Metro, 2018). The survey area includes the Orange Line from North Hollywood station to Canoga station. The four stations from, and including, Sherman Way to Chatsworth were not completed during the time of the survey and therefore not included.

The Los Angeles Metro Gold Line is a horseshoe shaped line that begins in East Los Angeles, runs toward the public transport transfer hub of Downtown Los Angeles, then continues north to South Pasadena and further through the City of Pasadena east towards Arcadia. The Gold Line travels mostly at grade, or slightly elevated but also has underground and elevated portions. The light rail line travels through dense communities in Downtown Los Angeles, Little Tokyo, Chinatown and Old Town Pasadena. Several cities are passed and navigated by this passenger rail line. Some stations on the Gold Line is similar to classical transit-oriented development design with a strategy and form that links nodes or destination hubs of commerce near town centres. However, the northeast expansion of the line runs above a freeway. While not so far from commerce the stations within and above the freeway represents a hazardous and psychological barrier for unadventurous pedestrians. Overall, the Gold Line has a diversity of contexts, station typologies and makes for an enlightening study for planners and researchers looking to invest in a public transport system that is lower cost than heavy rail or subterranean rail.

4.2.2 Gold Line Light Rail Stations

Table 2. Legend for identifying vacant or very low use lots near the Gold Line and Orange Line stations in Los Angeles County. Land use categories are from the Los Angeles City zoning plan.

Land Use Legend	
Parking lot at grade	(red)
Single family housing	(blue)
Vacant industrial or commercial	(yellow)
Lowest density single family housing and agricultural	(purple)
Vacant or low use light manufacturing	(green)
Other land uses	

4.2.2.1 Little Tokyo Station

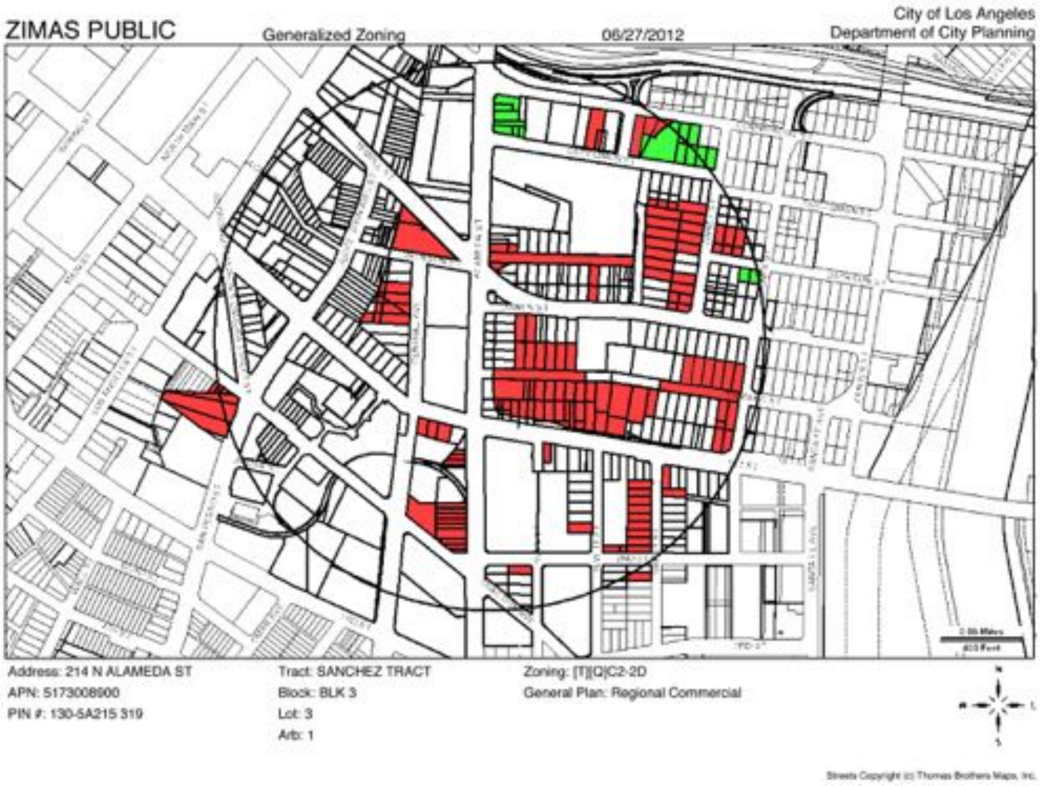

Figure 13. A black and white land use map of Little Tokyo Gold Line light rail station from http://zimas.lacity.org/, with undeveloped or low use lots noted in colour. At grade parking is shown in red and light manufacturing in green (adapted from City of Los Angeles, n.d.).

Little Tokyo station is located in Little Tokyo but actually hits on the fringe or edge of the pedestrian friendly downtown commercial districts. Little Tokyo's evolution has been similar to nearby Chinatown's but more rapid due to a location closer and more convenient to Downtown Los Angeles, by foot and passenger rail, as well as closer to the Union Station transport hub of the Los Angeles region and the headquarters of the county transport authority. Little Tokyo has been one of the success stories of the Community Redevelopment Agency of Los Angeles, with several overlapping resources, such as a contemporary art museum, a strong indigenous Japanese American population and cultural presence, and a nearby architecture school. Little Tokyo's station is on the fringe of this area and redevelopment efforts predates the Gold Line.

Notable characteristics of this tourist area are the large amounts of pay parking. The shaded areas in red are privately owned parking lots for profit. This land is already profitable with very little maintenance or operation required and while housing or shopping development opportunities might also be profitable, there are large start-up costs of construction and lag times during construction and before units are sold or leased that do not return a profit.

4.2.2.2 Soto Station

The Los Angeles Metropolitan Transportation Authority's (LA Metro) Soto station represents a typical condition along the Gold Line, and the urban context of Los Angeles in general. From the map, the area is shown to be made up from many small parcels owned by many different stakeholders in a strict grid fashion.

Figure 14. A black and white land use map of Soto Gold Line light rail station area from http://zimas.lacity.org/, with undeveloped or low use lots noted in colour. At grade parking is shown in red and light industrial or commercial is yellow (adapted from City of Los Angeles, n.d.).

4.2.2.3 Southwest Museum Station

The neighbourhoods and built context around the Southwest Museum station are an interesting contrast to Soto Station and show the hilly context of Los Angeles surrounding the flat basin of the centre and coast. The shaded areas in the map show the very low-density housing that has potential to become much denser through new development. High rise construction in Los Angeles has mostly been focused on the flat lands of Downtown Los Angeles, the great diagonal of Wilshire Boulevard and some other hubs such as Century City, with some exceptions. However, in other cities such as Hong Kong, high-rise developments have dominated the hills.

Medium density housing in this context might not be worthwhile as far as expensive retaining wall and foundation cost but, high density apartments or flats would be a reasonable thing to build here as tall buildings need deep foundations anyway and therefore wouldn't be deterred by the hilly context. High-density housing in this area would also be near to the small retail area below and the passenger light rail line.

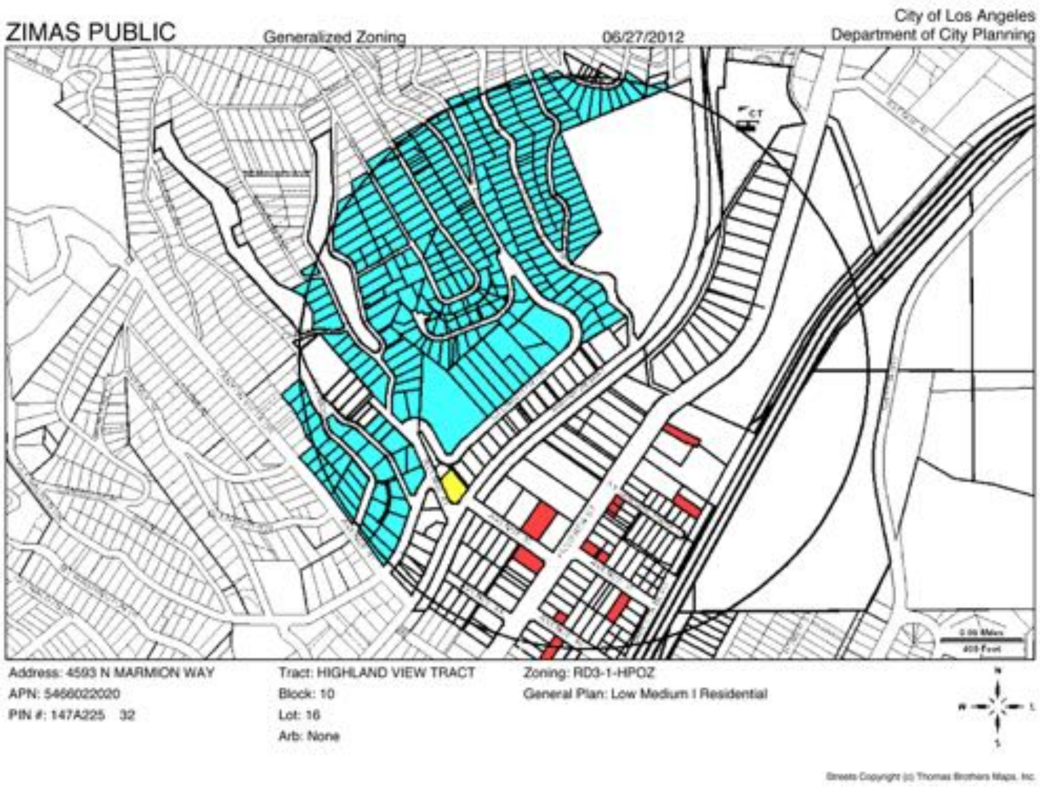

Figure 15. A black and white land use map of Southwest Museum Gold Line light rail station area from http://zimas.lacity.org/, with undeveloped or low use lots noted in colour. At grade parking is shown in red, low-density single-family housing in blue and light industrial or commercial is yellow (adapted from City of Los Angeles, n.d.).

4.2.2.4 Del Mar Station

The Gold Line runs through Pasadena that has natural, civic and cultural amenities. Pasadena has some of the best transit-oriented development and street interactive stops on the Gold Line. An historic resort town similar to Bath in England, Pasadena has a rich architectural heritage. Pasadena is also the location of the California Institute of Technology, the National Aeronautics and Space Administration’s (NASA) Jet Propulsion Laboratories (JPL) and the Huntington Library Art Collections and Botanical Gardens. Pasadena is a short Gold Line train ride to Downtown Los Angeles’ civic and financial centres as well as the University of Southern California.

Figure 16. Del Mar station designed in the New Urbanist tradition in Pasadena along the Gold Line light rail.

The southern leg of the Gold Line has great examples of transit-oriented development with rail developments integrated with the street and walking distance to commercial centres. Similar to these sensitive solutions is the Del Mar Transit Village was designed by the New Urbanist architecture firm Moule and Polyzoides. Del Mar station is a mixed-use development with market rate and affordable apartment units, retail, public plazas and underground parking for transit and residents.

4.2.2.5 Sierra Madre Villa Station

Figure 17. Sierra Madre Villa station, in the middle of a major freeway requires users to ascend a level, travel over the freeway, and descend to the platform for boarding.

To the north, the Gold Line runs in the middle of the busy 210 Foothill freeway. There are some commercial connections at Sierra Madre Villa Station, however they are disconnected from the station by a large freeway. However, this situation is the case in many cities implementing new public transport where city government or transport agencies build along existing rights of ways and along paths of least resistance. Unfortunately, this model of planning and construction, while practical, is planning passenger rail lines in an auto centric way. Routes along freeways feed to other roads but this is a lengthy pattern of travel for a pedestrian traveling from rail, up and over the freeway and down to any shops, connections, amenities or services.

4.2.3 Orange Line Bus Rapid Transit Stations

4.2.3.1 North Hollywood Station

North Hollywood is the first station of the Orange Line Bus Rapid Transit (BRT) and connects to the LA Metro Red Line underground that runs through Hollywood and Downtown Los Angeles. The areas surrounding the North Hollywood station are characterized by uneven development with large parking lots and residential towers or large shopping centres amongst low-density housing or vacant lots. North Hollywood is in the midst of a drawn-out redevelopment or urban regeneration. Super block development is more economical for developers and seems to be what is occurring in this neighbourhood, leaving a stark contrast between high-density residential buildings and vacant lots.

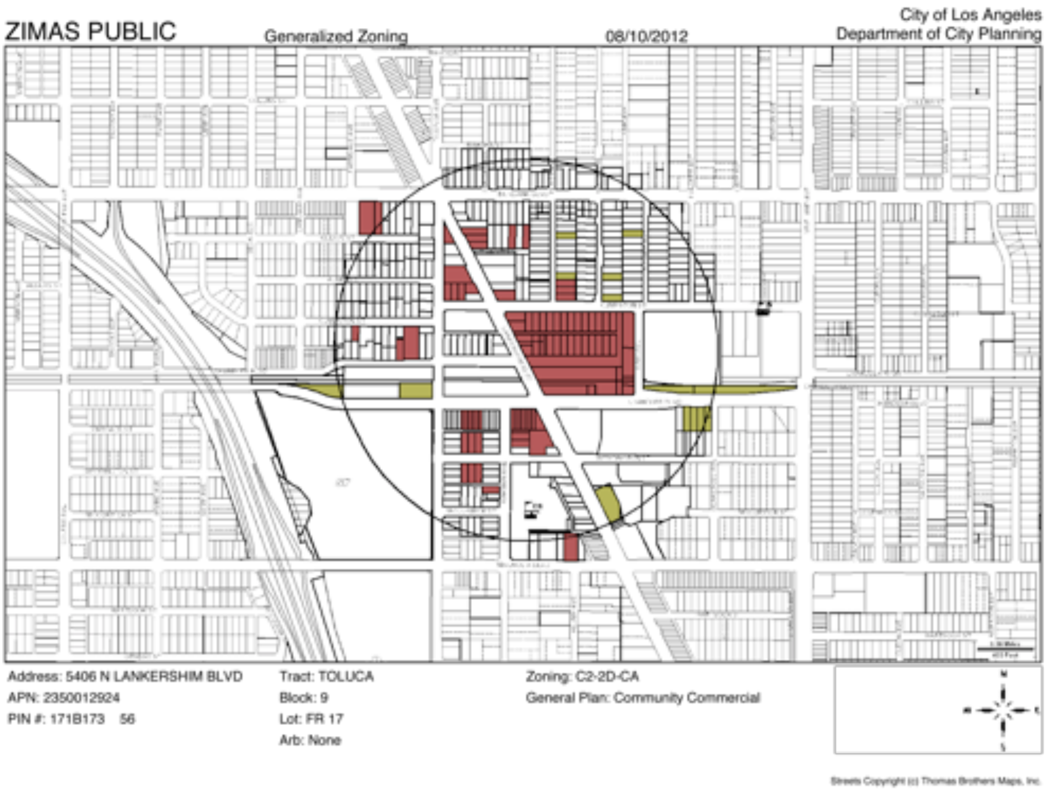

Figure 18. A black and white land use map of North Hollywood bus rapid transit Orange Line station from http://zimas.lacity.org/, with undeveloped or low use lots noted in colour. At grade parking is shown in red and light industrial or commercial is yellow (adapted from City of Los Angeles, n.d.).

At North Hollywood station and other Orange Line locations are transitional planning strategies with parking lots for transit under development or planned for development to mixed-use housing. The Orange Line itself was planned to transition into a light rail line when demand reached light rail levels yet, ridership on the Orange Line has surpassed estimated predictions and the transformation to light rail still remains only a plan.

The Orange Line was planned and implemented along two major routes, an alley like segregated bus path and beside major parks in the San Fernando Valley. Rational reasons for this seem apparent including a reduction of intersections with auto traffic and a path amidst public property ownership. A significant portion of the middle segment of the BRT and a third of the line is along preserved green space possibly causing a choice between preserved public green space and future transit-oriented development.

4.2.3.2 Sepulveda Station

Sepulveda Station is the first park edge station moving west from North Hollywood. Ensconced in the San Fernando Valley, which is a residential exurb with some office centres and retail or restaurants along large boulevards. Large amounts of parking, including for the BRT station, and low-density housing surround the station to the east and green space is to the west of the station. However, to the southeast, within walking distance are some commercial and retail locations. While these are still oriented towards the private car, these are retail resources that could be capitalized on with some clever planning and design interventions that take away parking and possibly add mixed-use development or at least shopping opportunities closer together for pedestrians.

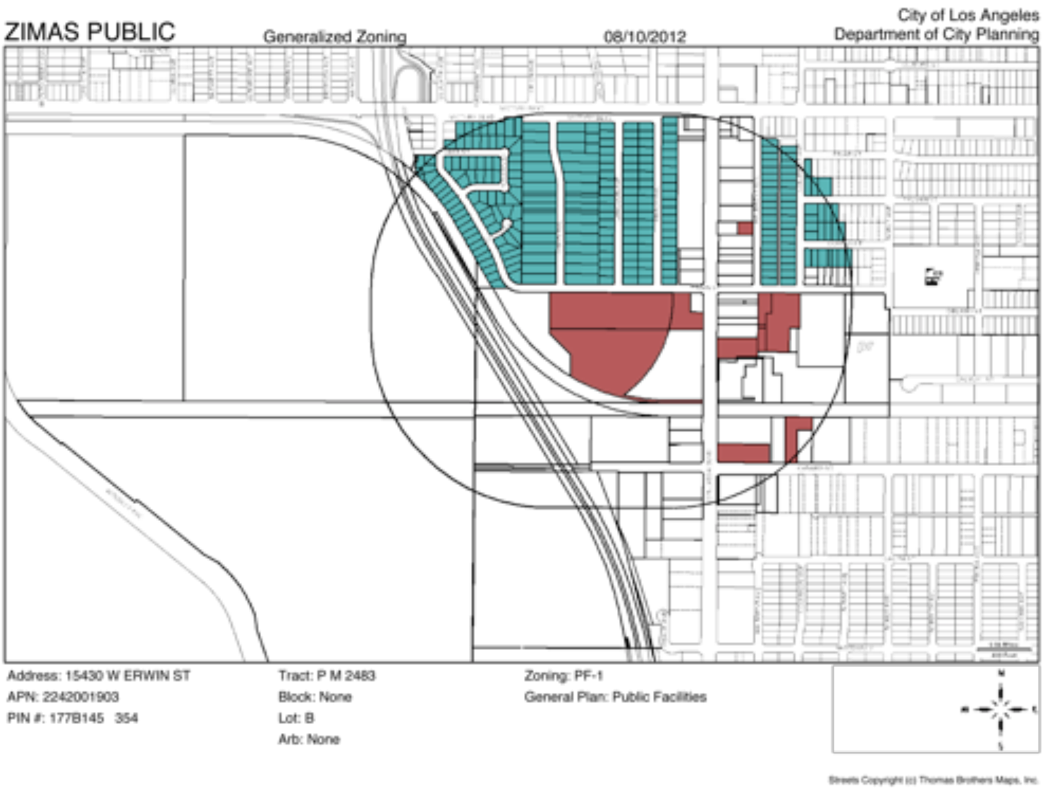

Figure 19. A black and white land use map of Sepulveda Orange Line bus rapid transit station area from http://zimas.lacity.org/, with undeveloped or low use lots noted in colour. At grade parking is shown in red and blue is single family residential (adapted from City of Los Angeles, n.d.).

4.2.3.3 Woodley Station

Woodley Station is another station in an island of park space with very little retail opportunities across seven lanes of auto traffic. At this point, the BRT path along the park is lined with shrubs and trees. However, if planned to travel through the park perhaps there are some nodes or destinations within the park to better connect to. It seems the current location of the BRT line is to provide easy access to it by car with parking just off of Victory Boulevard, a major thoroughfare of the San Fernando Valley.

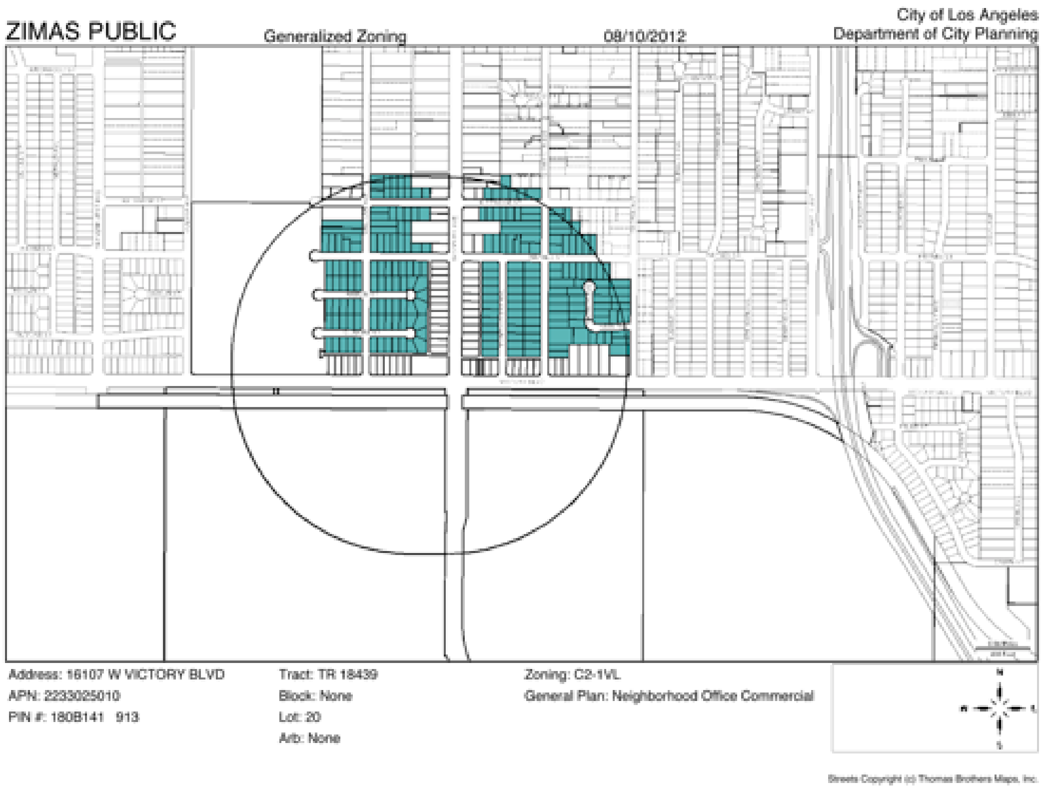

Figure 20. A black and white land use map of Woodley Orange Line bus rapid transit station area from http://zimas.lacity.org/, with undeveloped or low use lots noted in colour. Single family residential is in blue (adapted from City of Los Angeles, n.d.).

4.2.3.4 Balboa Station

The likelihood of Balboa station to have increased density with housing or commercial development is low, without some complex compromises or extensive planning ingenuity. Balboa station and Woodley station are located on the edge of the massive Balboa Park in the San Fernando Valley. Balboa station has some small amount of commercial and retail space nearby but also the sports field of a large school across the street. At Balboa station there is preserved open space, a school with large sports fields across the street and low-density housing. There is some commercial or office space nearby but it is unclear who might be walking to this station and it must predominantly be a park and ride station.

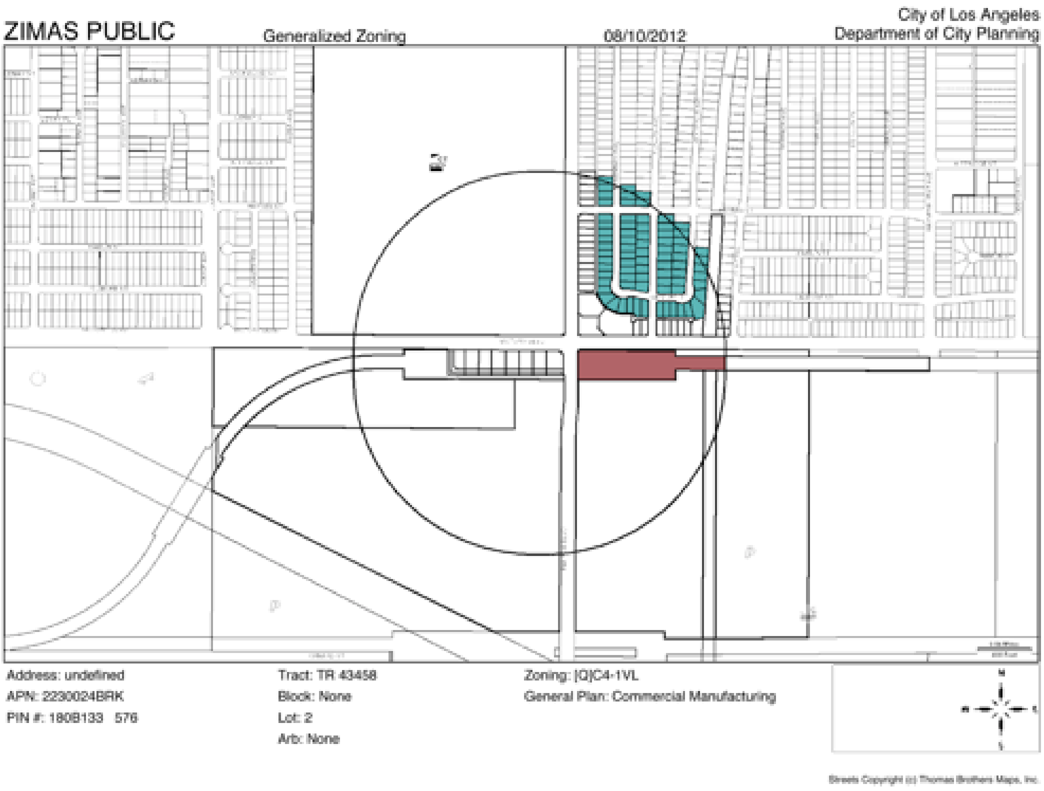

Figure 21. A black and white land use map of Balboa Orange Line bus rapid transit station area from http://zimas.lacity.org/, with undeveloped or low use lots noted in colour. At grade parking is shown in red and single family residential is shown in blue (adapted from City of Los Angeles, n.d.).

4.2.3.5 Pierce College Station

The next stop on the BRT is named Pierce College because of the nearby college it serves. However, the nearest college building is approximately 700 feet across parking lots and sports fields. Furthermore, these uses, while low or no density, may prohibit any development or economic catalysis because they do fill a need and are complete with stakeholders. In Woodland Hills, this northern part of the San Fernando Valley is usually very hot during the spring and summer months. Pierce

College Station is surrounded by residences, has plenty of trees and college students can be seen on the BRT. Unfortunately, there is no retail to be seen near the station to offer these users.

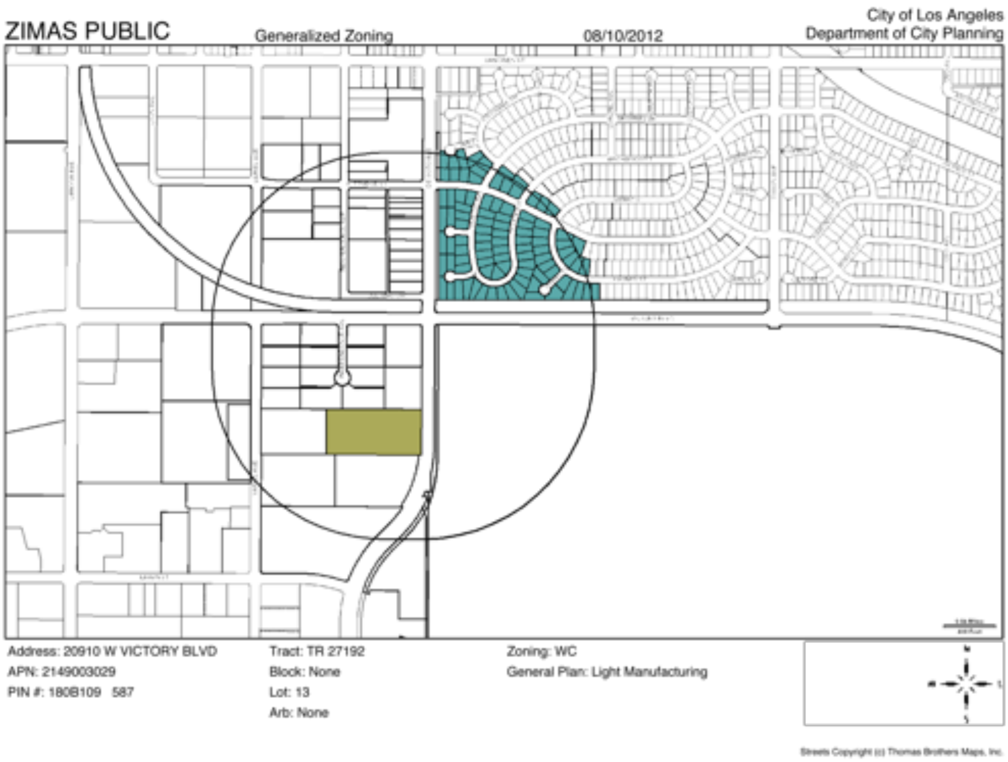

Figure 22. A black and white land use map of Pierce College Orange Line bus rapid transit station area from http://zimas.lacity.org/, with undeveloped or low use lots noted in colour. Low use industrial and commercial is in yellow and single family residential is shown in blue (adapted from City of Los Angeles, n.d.).

4.2.4 Mapping for Diagnosis Conclusions

The preceding land use analysis along two routes in Los Angeles have provided a backdrop for development challenges and the current context of the LA Metro system. The Orange Line Bus Rapid Transit and the Gold Line light rail offer a thorough understanding of the land use context of Los Angeles public transport and cover various parts for the city and station platform conditions. Large areas around two of the public transport lines in Los Angeles are composed of low-density, low-use, parking lots and vacant space. These are all challenges for derivative land use benefits of these transport lines, including associated walking trips. These are not supportive environments to encourage the use of public transport.

Near downtown Los Angeles and in some places in the San Fernando Valley there are industrial parcels, that may be providing a needed use but from this study some appear to be underused or even vacant. Industrial lots may be vital to the system of Los Angeles but there must be a way of integrating industrial land with new industrial uses or lot subdivision policies. Any city needs industrial or shipping distribution space as well as the other land uses.

Some suburban areas nearby the Gold Line and Orange Line are residential developments with curving roads that are cul-de-sacs and go through hills. Buses and public transport cannot navigate these streets and anyone wishing to take public transport must first navigate their way out. These winding indirect routes are not convenient for a pedestrian.

The geometry of the buildings in many of these areas is beyond a human scale with large open spaces or parking lots that must be walked across to the stations. However, even at this large suburban scale, there are parks, banks, well-kept sidewalks, office spaces and residences. With a strategic location of stations, and paths added and designed for direct routes for pedestrians the length of walking may be reduced so that shopping malls and office parks are more amenable for people on foot. Multiple bus stops could be introduced in areas like this, in a shuttle system fashion near shopping malls and office parks. A nodal attention or partial nodal strategy could improve connections and use with these far-reaching commuter bus and rail systems.

From this mapping analysis I noticed major problems for transit-oriented development near many of the Orange Line and Gold Line stations. While some were well placed, or in the case of the Gold Line accompanied by appropriate mixed-use developments and strategies, many stations played into the context of the previous auto-oriented street grid and culture. Particularly, the section of the Orange Line along the parks place the stations in virtually a park and ride only context, crippling any benefits or amenities of public transport beyond moving people from place to place. These stations located near public park space or amidst freeways are not available for a combined land use approach of pedestrian friendly transit-oriented development and the subsequent health and environmental benefits of denser living and walking trips.

There are some questions of geometry when looking at the big box buildings in the San Fernando Valley. Huge areas of space are owned by a single owner and large blocks are single parcels of ownership. A comprehensive re-dimensioning of lot lines and sizes in these exurb areas seems implausible but, allowing developers or owners to sell off the land piecemeal, or even encourage it through incentives or tax breaks, would diversify the land uses and their ownerships, while likely adding more density to the areas.

The Gold Line has inherent advantages over the Orange Line busway because the Gold line light rail travels through denser areas, older areas and stations were placed better. Some stations in Pasadena have a combined land use development strategy. The Orange Line, within large spread out spaces and with less pedestrians also has been the source of less transit-oriented development investment than the Gold Line that runs through Downtown Los Angeles and Pasadena. The Orange Line BRT has to do more with less. However, the north-eastern arc of the Gold Line light rail is also extremely problematic as it runs within a busy freeway.

This land use mapping study presented the land use challenges that affect the place relationships with public transport in Los Angeles. The next stages of the research presented in this thesis are underlaid by the conclusion that place, land uses and density, are currently a challenge for passenger rail success in Los Angeles. This experience and these conclusions set up the semi-structured interviews regarding transit-oriented development efforts and strategy in Los Angeles. This is based on the presumptions explored in the literature review that place is integral to passenger rail ridership and return of subsequent and derivative benefits.

4.3 Interviews and Planning Document Analysis

Intensification is a common planning goal in many countries (Duffhues, 2016). Los Angeles is currently the site of many intensification tools from passenger rail transit-oriented development to street reclamation and bicycle lane implementations. There is no doubt that today the automobile is the major transport mode in Los Angeles. At the same time, the amount and rapidity of public transport and intensification achievements in the city makes for an excellent case study of how a city can change its urban form. The following is an analysis of efforts and aims in Los Angeles developed from interviews with planning officials and research of planning documents. This will provide key background and understanding for the subsequent statistical analysis.

Several local, regional, and state transportation agencies interact in the Los Angeles region. Research through interviews, mapping and ethnography was needed to understand the political milieu and the issues that Los Angeles has and that the planning officials are working on. Public transport built architecture is a commonly an expression of these agendas and collective desires (Cochrane and Ward, 2012; Harris, 2008; Hillier, 2011; McFarlane and Robinson, 2012; Robinson, 2006, 2011).

The research in this chapter includes interviews and planning document analysis that sets up the statistical analysis in Chapter 5. Information comes from semi-structured interviews with academics, planning officials and practice professionals including architects and urban designers. While there is some overlap in roles, two architects and one urban designer with experience in rail station design were interviewed. University lecturers and professors in Civil Engineering, Urban Systems, Development Studies, Political Science, Transport, Architecture and Urban Design were all interviewed with prompts and open-ended questions for thirty minutes to one hour. Similarly, four employees of the Los Angeles County Metropolitan

Transportation Authority (LA Metro) were interviewed that work in joint development and environmental compliance were interviewed. A Principal Transportation Engineer from the Los Angeles Department of Transportation was interviewed, as well as two City Planners from the Los Angeles City Department of City Planning, and a Policy Director from Occidental College working on research and policy guidance for LA Metro. These interviews are roughly evenly distributed over the course of 2012, 2013 and 2014.

A more extensive analysis of recent planning documents from the public planning agencies of the city of Los Angeles was conducted to see if land use development was as much as a commitment in text as it had been in the interviews. Eighteen recent planning documents were scanned for the key phrases that were distilled from the interview phase. The key terms were combined from the interview text. These documents were from city and county agencies including the LA Metro. The plans focused on a range of topics including sustainability, energy, mobility, climate, water and transit. These documents were tangential to land use development yet development was noted throughout these documents. Several quality of life or urban design attributes were distilled through NVivo qualitative analysis software, including the terms bicycle that was mentioned 4129 times, street at 1828, rail at 1258 and development at 1030 with the general terms design and quality being in the top third of the 56 terms analysed, shown in Table 3.

This content analysis gives a picture of what the motivations and concerns are in contemporary planning in Los Angeles. However, the analysis does not necessarily provide a measurement of outcomes. A site analysis is necessary to compare the built realty with these official promotions.

Table 3. List of the most found topics in planning documents.

Text searched	**Number of references**	**Text searched**	**Number of references**	**Text searched**	**Number of references**
Bicycle	4129	Car	281	Bus rapid transit	32
County	3077	Renewable energy	277	High-speed rail	32
Street	1828	Walk(ing)	276	Affordable housing	27
Policy	1339	Environment	235	Centers for Disease Control (CDC)	25
Planning	1292	Health	226	Regional connector	23
Rail	1258	Climate change	168	Underground	21
Development	1030	Density	146	Profit	20
Parking	742	Light rail	137	Joint development	19
Authority	682	Downtown	114	Toll	19
Design	661	Equity	90	Land development	18
Land use	597	Subway	69	Seamless transport	18
Quality	518	Target	63	Public private partnership	14
Buses	411	Public health	60	First mile last mile	13
Pedestrian	378	Collaboration	56	Urban design	11
Demand	367	Food	51	Synergy	3
Greenhouse gas emissions	361	Auto	44	Carbon credit	2
Road	339	Diversity	43	Carbon reduction	2
Efficiency	328	Transit-oriented development	40	Value capture	1
Regions	328	Timeline	39		

4.3.1 Current Land Use and Sustainable Mode Integration Issues

The stations of the LA Metro are predominantly at grade, with many underground and some elevated stations. These are incorporated into the city at the street level as well as underground or with elevated walkways. There are some common issues with building in an existing urban context when it comes to the path of rail. Planning and tunnels must allow for speed and no impediments. Noise is also a substantial concern regarding rail in California with speed limits put on some places. The following presents major topics of discussion from the interview and document analysis that pertain to the relationship between place and public transport.

4.3.1.1 First Mile and Last Mile

Another major priority for the transport professionals and stakeholders in Los Angeles is the disconnection of the first and last mile, in other words, how people make their connections to rail lines. The Los Angeles Department of Transportation, amongst other transportation agencies, intend to address this problem with mobility hubs at some rail stations and eventually more (Los Angeles Department of Transportation, 2015; Los Angeles Department of Transportation Bike Program, 2016). A trip on public transport usually requires a transfer and the added wait times of waiting for a connection. These connection times add up and are a factor in someone choosing to drive instead of wait for a bus. There are many ideas for these mobility hubs including bike share programs, car shares and safe bicycle parking all organized through mobile internet services. The LA DOT has grant funding for 5 major hubs including Hollywood, Downtown Los Angeles and Long Beach as well as funding for 10 further hubs (Los Angeles Department of Transportation, 2015). They hope to build confidence in the system's ability to go anywhere in Los Angeles and for the experience to be seamless and easy.

The first integrated mobility hubs will be at three strategic locations, Hollywood, Downtown Los Angeles, and Long Beach. The 3-year demonstration project is funded from a variety of sources including $US 3.2 million from LA Metro, $US 8.4 million from the Federal Transportation Authority's Job Access Reverse Commute (JARC) program grant, and $US 5.0 million from local private partners (Southern California Association of Governments and the City of Los Angeles, 2010).

These mobility hubs incorporate the notion of integrated transport and multi-modal connections. Other examples include the Los Angeles City Bicycle Master Plan that was adopted in 2010, and the Los Angeles County Bicycle Plan adopted in 2012 (City of Los Angeles Department of City Planning, 2011; County of Los Angeles, 2012). The Los Angeles City Bicycle Plan has a five-year implementation strategy that requires at least 200 miles of bike routes in that time (City of Los Angeles Department of City Planning, 2011). Currently, there are car-sharing programs near the University of California Los Angeles and the University of Southern California that are planned to be expanded via the new mobility hubs, in combination with new electric vehicle charging locations (Newton, 2012). A bike share program was also launched in 2012 (Bloomekatz, 2012a). These variety of modes integrated at hubs will provide modal options that better compete with the private through a flexibility of connections.

Other small grant projects include street reclamation projects to enlarge park space and improve the pedestrian realm. These reclamation projects, while small in funding, involve several different stakeholder groups to implement and maintain them including small businesses. The Silver Lake Improvement Association signed a maintenance and liability agreement. These small projects might only involve painting and diverting traffic but can make a big difference in the pedestrian friendliness of the street and can be completed in a few months with meagre funding. Funding comes from the United States Centers for Disease Control and the Los Angeles Department of Public Health to create more walkable neighbourhoods and reduce obesity (Los Angeles Department of Transportation, 2015). Bicycle stands, chairs, planters and trees further make the park more usable and integrated into people’s routines. The Department of City Planning has also promoted pedestrian environments through walkability checklists, plans and design guidance.

In addition to mobility hubs, the LA DOT works on a variety of projects to solve the first and last mile problem and increase public transport use for a more balanced share of transport. These include a Bus Rapid Transit lane on Wilshire Boulevard, a major diagonal artery in Los Angeles (Los Angeles Department of Transportation, 2015). The LA DOT is also experimenting with smart meters to better simulate market prices for metered parking. Smart technology will price parking spaces based on demand from time of day and will notify drivers when spaces are available. The strategy argues that motorists will be encouraged to park in off street parking structures and thereby reducing congestion on the streets. Funds of 15 million United States dollars were made available from the United States Department of Transportation as well as 3.5 million dollars in funds from the City of Los Angeles (Groves, 2010). There is also funding for reverse commuting for people commuting from central low-income neighbourhoods to work outside the centre.

Other major issues and awareness in Los Angeles is the need for bicycle lanes and transport. The City of Los Angeles has developed a bicycle master plan and is attempting to implement 265 miles of bicycle lanes within a five-year time frame (Los Angeles Department of Transportation Bike Program, n.d.a).

The Regional Connector Transit Corridor is an on-going project that seeks to connect three rail lines in downtown Los Angeles (Los Angeles Metropolitan Transportation Authority, 2012d). The 1.9-mile project will provide passengers with continuous service without transfers from the eastern ends of the rail system to the western destinations (Los Angeles Metropolitan Transportation Authority, 2012d). Currently the two major hubs of Downtown Los Angeles, Union Station and 7th Street only have two underground lines that connect to each other with a possibility of five that will connect after the Regional Connector underground tunnelling is completed. The project has received little opposition, possibly because of the low numbers of residents in the project area that is predominantly downtown office and tourist destinations. The Regional Connector is also an example of the type of project necessary in urban transport retrofit. When the built form is established, projects happen in a piecemeal fashion as a result of neighbourhood opposition, political opinions waxing and waning, building policy and government regime changes, as well as existing urban fabric that must be navigated.

4.3.1.2 Land Use Strategies in Los Angeles

Interviews in Los Angeles brought up some interesting challenges to promoting public transport for environmental benefit and public health. Due to construction emissions and expanding rail, greenhouse gases will grow and take some time before there is a reduction. LA Metro reduces its own C02 footprint as much as possible. Plans for electric car parking for its employees and electric buses are underway. At the consumer end some toll lanes have been introduced on the freeways and drivers in Los Angeles are being introduced to paying for road travel. Previously car pool lanes have acted as express lanes for cars with two or more passengers. The buses also use these express lanes. Many of these projects have a demonstration aspect to them hoping to encourage sustainable travel in people's habits. Often these projects hope to bring awareness to these issues and promote behaviour change and more sustainable mode choices in residents. New funding stream from the Centres for Disease Control, example, show that awareness is growing for the relationship between active transport modes and the concerns for the environment and public health.

Other problems arose during my interviews concerning the complex relation of constructing a way out of environmental damage from emissions of vehicle miles travelled. There is usually a relationship between speed and carbon footprint. For example, a high-speed rail will need better infrastructure and more energy than a tram. These environmental impacts can be mitigated by finding a passenger miles travelled threshold that provides the most benefits, or reduced environmental costs, for the fiscal or environmental costs. The LA Metro also found that while bicyclists are a small fraction of rail riders that they were significant and offered insight into how to reduce vehicle miles travelled and emissions (Los Angeles Metropolitan Transportation Authority, 2011). Bicyclists are also a significant stakeholder in Metro rail because they use 71 out of 73 stations (Los Angeles Metropolitan Transportation

Authority, 2011).

4.3.1.3 Joint Land Use Development

The LA Metro owns a large amount of property and works with developers to construct predominantly mixed-use housing complexes. LA Metro as a public owner of these products has some powerful benefits, such as their ability to stipulate what is needed in the area rather than just profits, including affordable or public housing.

Different funding may have different requirements of what LA Metro can build on the property. LA Metro enters into an exclusive agreement once a developer for a site has been approved and the developer has money to begin. The proposed development must be approved according to the California Environmental Quality Act's standards. Afterwards, a Joint Development Agreement is established between LA Metro and the Developer. LA Metro supplies a lease for development. This provides LA Metro with income and the developer can offer businesses a location with many people walking by to use the trains or can attract people that want to live by public transport to residences. An exception to this rule is a public school at the Wilshire and Vermont station. Public schools cannot lease their properties in Los Angeles. Otherwise, each ground lease is for 55 or 99 years in a system more commonly used abroad. These deals can be renegotiated and individuals can lease within the life span of the developer's lease.

4.4 Context Issues in Los Angeles

Topics of seamless transport, land use adaptation for transport or other means, multi modal transport systems and the idea of hubs were the major reoccurring topics from the Los Angeles interviews. An engineering attitude of fine-tuning the transport system is an effort to attack problems from a variety of partial methods. The largest stroke of reengineering is the subway and light rail additions that affect thoroughfares of the city with acupunctural investments and land use change along corridors. Plans for projects, included bicycle lanes, rather than a powerful master plan to reorganize the city at once.

Ideas and projects were in heavy supply. However, The Los Angeles Metropolitan County Transportation Authority and their subway and light rail lines are the largest in size and investment to make great change across Los Angeles in terms of physical, environmental, economic and behaviour change. The several sales tax incomes that the agency has, especially the measures that go straight to them for allocation, are substantial in capital. While the piecemeal projects are interesting and most likely to be completed their effects will likely be neighbourhood centric.

The California High-Speed Rail project's implementation created a lot of enthusiasm within the urban transport and planning professionals in Los Angeles, especially for the opportunity to upgrade rail beyond the high-speed path, yet construction is behind and it is unclear when benefits will materialize. The plans are to use high-speed rail funding to improve the connecting lines to the high-speed rail stations; those upgraded portions may presumably be used for trips besides to and from high-speed rail and upgrades may even include some new development components and resulting benefits. However, construction has been intermittent due to funding challenges and political obstruction.

Other plans like walkability design guidance, a new streetcar in Downtown Los Angeles, street reclamation for parks and bicycles, smart parking and the efforts of civil society through bicycle festivals or efforts to attract retailers were like wise one-off efforts without ambitious returns on investment. Overall, the strategy is to come at the transport system from multiple projects and funding sources with the importance of agency collaboration being key.

The joint development housing efforts of LA Metro may be the most tangible land use, non-transport benefit to come out of the transport agendas in Los Angeles. With sixteen large mixed-used housing developments across Los Angeles, the city can implement housing for the public good, such as affordable housing or public housing (Los Angeles County Metropolitan Transportation Authority, n.d.b).

Furthermore, lease incomes from these properties return to LA Metro for further public works. Over 2000 housing units have been completed with over 1 million square feet of office and retail completed (Los Angeles County Metropolitan Transportation Authority, n.d.b). Two more projects are under construction and six more are in negotiations (Los Angeles County Metropolitan Transportation Authority, n.d.b). However, LA Metro has been largely passive with advertising their leasable land to developers and could be much more active in promoting these projects.

Land use development, the provision of amenities at stations, and the importance of connectivity such as mobility hubs, walkability plans and bus and bicycle connections were common topics of discussion. The recurring attention of land use factors in these interviews brought my attention to the importance of the built environment for public transport's success. This process also encouraged me to argue for a further land use component in transport planning by asking how land use or station context supports public transport ridership. If a clear relationship between context attributes and public transport success can be made, then a realignment of efforts can be argued to focus on land use change as well as public transport investment. A new more robust system of planning could be termed place and public transport.

4.5 Next Steps

From the interviews with transport planning professionals and the subsequent planning document search it becomes clear that land use intervention in the form of development is the major topic of concern and intention to city planning professionals, researchers, architects and engineers in Los Angeles. This formative phase of research unearthed conclusions regarding the intentions and goals of the transport agencies. Joint development, transit-oriented development and sustainability were topics of concern and promotion in interviews and agency publications. The next step of this thesis is to analyse the relationships between transport and the built environment around stations.

After this form of context analysis, it is clear that a study of the built environment of Los Angeles is of importance. There are a couple different ways to proceed. A study of the housing developments implemented by LA Metro, in order to compare the intention with the outcomes would be important but while their developments are impressive, they are only a small fraction of the housing in Los Angeles. If development is such an agenda for the transport planners in Los Angeles it is important to provide them with data for why and how land use development change is supportive of passenger rail and public transport in general.

The following statistical analysis looks at place as the key component of public transport. The next steps will show a computational argument for why place matters to public transport. This analysis it gives credence to the transport planners' pro development agenda. The statistical steps also take into consideration the interrelation of factors such as transit-oriented development, passenger rail, economics and sustainability. By understanding how context and place demographics correlate and affect passenger rail, an argument for a greater share of land use development in public transport planning is made.

5 Bivariate Pearson Correlation and Linear Regression Analysis Los Angeles

The second research step uses a statistical analysis to further investigate correlations between urban environment attributes and passenger rail ridership. This incorporates a large body of census data with data from the site surveys based on location of passenger rail stations to test them for a relationship with ridership. A correlation analysis was performed on 91 passenger rail stations in Los Angeles with 66 variables from sources including the U.S. Census and metrics from other agencies to find which variables correlate with increases or decreases in ridership. From identified correlated variables, a single regression and a multivariate regression were performed. Station name or ZIP Code were the cases studies and useful for determining spatial considerations. Identified relationships between variables and station passenger rail ridership are discussed in the following.

5.1 Bivariate Pearson Correlations

5.1.1 Positive Correlations

The positive and negative correlations of variables with ridership are shown below with the variables where no correlation was found by this experiment listed in an appendix. Fourteen variables where found to have positive correlations with transport ridership, as one goes up so does ridership and they are mutually beneficial. Some of these strengthen preliminary conclusions from the site analysis, some offer new insights and some reinforce the robustness of the study proving that the analysis is performing properly. Essentially the negative correlations argue that wealth and passenger rail use have inverse relationships similar to many other studies (Farber et al., 2014; Fu and Juan, 2015; Gong and Jin, 2014; Pasha et al., 2016). Driving to work and availability of cars also have inverse relationships that correspond to other research on the subject (Dieleman and Guillaume, 2002).

Table 4. Positive correlations with passenger rail ridership ranked by strength of correlation.

Variable Correlating Positively With Ridership	**Pearson Correlation***	**Significance of The Null Hypothesis**
Number of Rail Lines	0.543	0
Percentage That Taxi, Motorcycle or Other to Work	0.521	0
Type of Rail, Correlated With Heavy and Underground Rail	0.513	0
Bicycle Rack Spaces at Station	0.378	0
Household Residential Density Near Station	0.37	0
Transit Score From Walkscore.com	0.361	0.002
Percentage That Took Public Transport To Work	0.336	0.001
Paid Parking at Station	0.308	0.003
Percentage With no Vehicle Available	0.284	0.006
UC Berkeley Center for Law, Energy and the Environment Transport (CLEE) Station Metric	0.28	0.011
Individuals Below The Poverty Line	0.224	0.032
Model of Station, Super Hub or Hauptbahnhof Type	0.221	0.035
Number of Vacant Housing Units	0.211	0.045
Population Density Near Station	0.206	0.05
* The positive correlation is more strongly correlated as the Pearson correlation approaches positive one.		

5.1.1.1 Access or Connections of Stations

The number of rail lines a station has available has the strongest positive correlation with ridership. In Los Angeles, the more lines a station has, the more ridership it will have. This matches with the literature on the necessity of complexity and a certain size of transport system before use and benefits are significantly returned (Cervero and Guerra, 2011; Guerra and Cervero, 2011; Guerra et al., 2012; Guerra and Cervero, 2010). In Los Angeles, the major transfer stations Union Station and 7th

Street Station. Both are central locations with mixed-use attributes. The transit score metric, or how well appointed the transit options are in that area, coincided with higher ridership, which makes sense. Two other connection attributes also correlated with positive ridership including the availability of bicycle racks and paid parking spaces. Despite the many land use missed opportunities that park and ride stations exhibit, at least the paid parking at these stations is being used and correlates with transit users. In the literature, parking at stations correlating to ridership has varied by place (Meek et al., 2011; Mingardo, 2013). Free parking at stations did not correlate with ridership, positively or negatively in this analysis.

5.1.1.1.1 Travel Behaviour

No access to a vehicle also correlated with positive ridership matching the literature on car ownership's inverse relationship with public transport use (Dieleman and Guillaume, 2002). Taking a taxi, motorcycle or other to work correlated positively with ridership, perhaps showing that these lighter modes are used in connecting to public transport.

5.1.1.2 Density

Household density and population density were both associated with positive ridership. In Los Angeles, this reinforces claims about the relationship of ridership and density (Mees, 2010). These results correspond with other studies on density (Boulange et al., 2017).

5.1.1.3 Individuals Below the Poverty Line

Number of individuals living below the poverty line correlated positively with ridership agreeing with the literature on the inverse relationship between wealth and public transport (Dieleman and Guillaume, 2002; Fu and Juan, 2015; Pasha et al., 2016).

5.1.1.4 Architecture, Design or Technology

The underground heavy rail type of system line, the Red Line and Purple Line, with their faster speeds and without interactions at the street level, has a strong positive correlation with ridership. Underground lines in Los Angeles, move faster because of no intersections and their faster propulsion type but also, have been placed across the central city dense mixed-use area. Furthermore, one of these lines is the second oldest in Los Angeles with people used to it and has been the site of the majority of densification projects of the LA Metro. The model of station, whether the station is underground, at grade or elevated has resulted with a positive correlation with underground station conditions associated with positive ridership.

5.1.2 Negative or Inverse Correlations

The negative correlations found show an inverse relationship between aspects of wealth, such as median income and home ownership with passenger rail ridership in Los Angeles. Other methods of travel to work besides passenger rail also inversely correlated with passenger rail use, obviously. Ten attributes are shown to have a negative relationship with ridership.

Table 5. The negative correlations with passenger rail ridership ranked by strength.

Variable Correlating Negatively With Ridership	Pearson Correlation*	Significance of The Null Hypothesis
Transportation Affordability as Percentage of Income	-0.381	0
Home Value Percentage Change for Year 2015 - 2016 From Zillow	-0.362	0.001
End Station Configuration	-0.34	0.001
Bicycle Score Metric From Walkscore.com	-0.299	0.01
Percentage That Drove Alone to Work	-0.263	0.012
Percentage of Area's Population With 3 Vehicles Available	-0.251	0.016
Percentage That Took Car, Truck or Van to Work	-0.249	0.018
Median Household Income of Surrounding Area	-0.233	0.026
Owner Occupied Housing Units in Area	-0.227	0.03
Percentage of Area's Population With 2 Vehicles Available	-0.213	0.043
* The negative, or inverse, correlation is more strongly correlated as the Pearson correlation approaches negative one.		

5.1.2.1 Access or Connections at Stations

End stations are strongly negatively correlated with ridership, meaning that these stations have lower ridership typically than through stations. A preliminary explanation for this is that the end stations of the Los Angeles light rail lines end in suburban areas of lower density.

5.1.2.2 Bicycle Environment

The metric of the quality of the environment for bicycle riders also shows an inverse correlation with ridership. Improving the bicycle quality of station areas might be an opportunity for the LA Metro to improve ridership. Cycling and its relationship to passenger rail has not been studied sufficiently and remains an area of limited research (Frank et al., 2016).

5.1.2.2.1 Travel Behaviour

The percentage of people in the station area that drove alone to work, as well as those that took a car, truck or van to work logically correlated inversely with passenger rail use.

5.1.2.3 Wealth Aspects

How affordable transit is to people in the surrounding area of the station showed a negative relationship with ridership, again showing that wealth has an inverse relationship with passenger rail use in Los Angeles like many other places (Badland et al., 2017; Boulange et al., 2017; Dieleman and Guillaume, 2002; Pasha et al., 2016; Yao, 2007). Home value increases, as well as owner occupied housing also correlated negatively with ridership. Wealth indicators such as car ownership and median household income correlated inversely with ridership similar to many other studies in this field (Badland et al., 2017; Boulange et al., 2017; Dieleman and Guillaume, 2002; Pasha et al., 2016; Yao, 2007).

5.1.3 Cross-Correlations

Some cross-correlations between variables besides ridership were interesting and seem predictable. No vehicle available correlated with those taking public transport to work. Higher incomes correlated with those that had two vehicles available as well as driving alone to work. Owner occupied housing and veterans correlated with each other and possibly showing that veterans have a higher income explaining the inverse correlation with passenger rail use. However, more research is need to explain this relationship between veterans and driving in Los Angeles. Overall, several indicators of wealth correlate with each other and inversely correlate with passenger rail ridership.

Table 6. The high correlation of variables with each other rather than passenger rail ridership. Correlation coefficients above .700 from a Pearson correlation matrix are shown below. A correlation is stronger as the coefficient approaches positive one.

	No Vehicle Available	UC Berkeley CLEE Score Station Rankings	Drove Alone to Work	Percent With 2 Vehicles Available	Percent With 3 Vehicles Available	Owner Occupied Housing
Public Transport to Work	0.881	0.753				
Median Household Income			0.790	0.872		
Car, Truck or Van to Work			0.969	0.781	0.766	0.731
Percent With 2 Vehicles Available			0.848			
Owner Occupied Housing					0.725	
Transit as a Percent of Income					0.711	

5.2 Multiple Linear Regression of Identified Variable Relationships

Linear regression is an analysis method used in predicting an outcome. Linear regression can be done with one or multiple variables to determine their prediction, or effect on a dependent variable, in this case their effect on passenger rail ridership (Field, 2009). The following regression analysis involves the identified correlating variables that were found to have a relationship with passenger rail ridership. These tests explain how much of passenger rail ridership is explained by these specific predictor variables.

Firstly, looking at the R2 value in Table 7, the model predicts approximately 62% of passenger rail trips at a station for the 83 station cases tested. The R2 explains the amount of variance that the model explains due to the predictor variables (Field, 2009). Preparing this data for statistical analysis required several tests to build a normal body of data to be tested. Due to collinearity several variables had to be excluded because their identity was too similar to other variables in the model and they were confusing the appearance of the relationships (Field, 2009). Certain outlier stations also had to be removed from the model, such as the busy 7th street station, partly because the ridership numbers were so much larger than the majority of station ridership numbers. This final model has less variables, accounting for the predictive power that conservatively explains 48% of ridership. Eight outliers have been excluded because of their undue weight on the model, with 83 passenger rail stations remaining.

The remaining test included 83 stations in Los Angeles by 13 discrete variables. Eight of these 13 variables were found to have a significant individual impact on ridership. However, this more accurate and smaller multiple regression has a smaller explanation of ridership but more confidence in conclusions. Histograms, P-Plots and scatterplots are used to judge the quality of the model. Figures 23 and 24 show the histogram, P-Plot and scatterplot looking as they should, showing that his model is reliable and accurate.

Table 7. Model summary of multiple regression.

Model Summary of Precision Model	R	R^2	Significance of Null Hypothesis
	0.785	0.616	.000

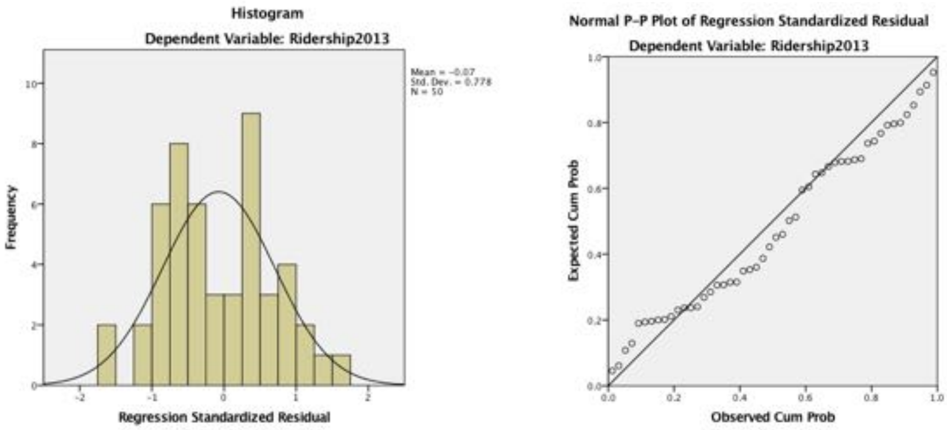

Figure 23. Histogram and P-P Plot of the model.

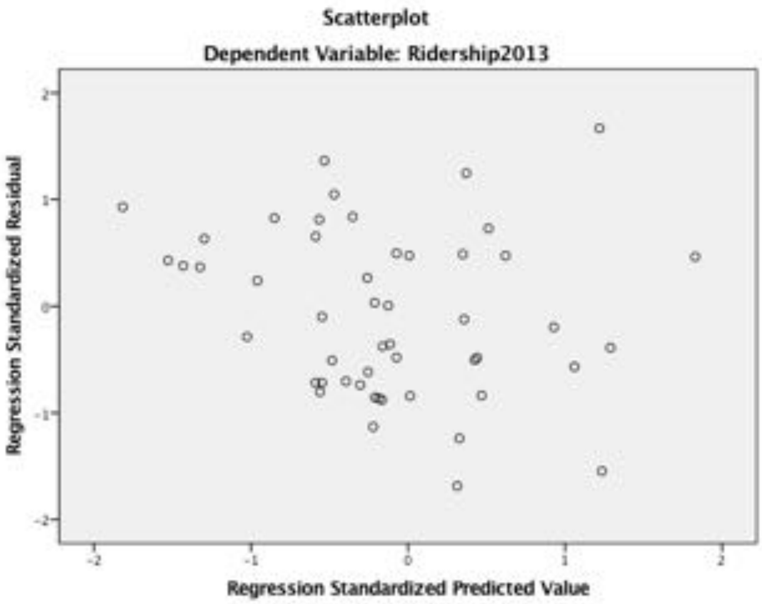

Figure 24. Scatterplot of the model.

In this multivariate linear regression there are a several discoveries that city planners and the LA Metro should look into and invest in. The following is a prediction of the variables individual impact on ridership. The part correlation, or semi-partial correlation, measures the relationship between two variables while controlling for the effect of other variables (Field, 2009). This is the measure of the variance of the isolated variable that shares the variance of passenger rail ridership (Field, 2009). The singular impact of the variable upon passenger rail ridership is computed by squaring the part correlation coefficient for a per cent isolated impact on ridership (Field, 2009). These individual impact factors are larger when combined with other variables (Field, 2009). A 1% finding below in Table 8 may be much larger when combined with other variables as they interrelate. The results of these computations are discussed in the following text.

Table 8. The variables’ percentage of the R square value or the power on the output of passenger rail ridership. The final calculation shows the singular impact or weight the variable has on passenger rail ridership.

Variable Tested Against Ridership	**Part Correlation Coefficient**	**Part Squared**	**Percentage Singular Impact on Variance In The Model**
System Type, Heavy and Underground Rail	0.121	0.014641	1%
Model of Station, Super Hub, Hauptbahnhof Style Station	0.268	0.071824	7%
Number of Rail Lines Available	0.272	0.073984	7%
Individuals Below the Poverty Line	0.121	0.014641	1%
Vacant Housing Units	0.219	0.047961	4.7%
Population Density	-0.102	0.010404	1%
Bicycle Score	-0.243	0.059049	5%
Zillow Home Value Change	-0.225	0.050625	5%
Total singular impacts on the outcome of ridership, when combined with each other these are likely larger predictors of variance (Field, 2009)		**0.351939 or < 35%**	

5.2.1.1 Access or Connections

One of the largest results was the number of rail lines, or destination possibilities, has an individual impact for 7% of ridership. In this model, another negative impact is the bicycle score or the atmosphere for bicyclists’ metric with a 5% negative individual impact on ridership. A poor environment for bicycles has a negative impact on ridership. However, this metric needs to be examined in order to find out what qualities beneficial to bicyclists negatively affect passenger rail ridership. The results on bicyclists and their environment clash with ridership that requires more study beyond this thesis and possibly a notice to the transportation authorities that more care should be considered to provide for bicyclists. Bicycles as a connecting mode to rail is also significant. Sustainable mode connections, including bicycle use, have been identified as increasing in use, user priority and as keys in environmental benefit return and quality of life (Badland et al., 2017; Boulange et al., 2017; Krizek, 2003; Ksiqzkiewicz, 2012). Access and mode connections have been connected to upward economic and educational mobility as well as many other beneficial outcomes (Chetty et al., 2015; Rothwell and Massey, 2015).

5.2.1.2 Density

The more sustainable modes of transport like bicycles and walking embellish and interact with the place and built environment. A station area's population density accounts for 1% individual impact on ridership. With 113,168,661 boardings on passenger rail in Los Angeles County 1% individual impact is 1,131,686 boardings per year. This is likely more when these variables are amplified in combination with each other, since these are only the parsed percentage and these weights change in aggregates (Badland et al., 2017; Boulange et al., 2017; Guerra et al., 2012; Metz, 2013). In Los Angeles, we can say that density does encourage passenger rail use.

5.2.1.3 Wealth

Vacant housing units account for an individual impact of 4.7% on ridership. This result is outside of the scope of this thesis to explain; however, this is a finding that LA Metro and transportation authorities should keep in mind. This percentage may even be the results of gentrification due to transit-oriented developments and displacing the previous population. New transport should not be placed in areas with high numbers of vacant housing according to the findings of density encouraging passenger rail ridership and other research on this matter (Dulal et al., 2011). One strategy may be to locate in areas with ongoing construction of housing, vacant at the moment, but in the process of adding housing units for the new transport line.

Home value change is another instance of wealth having an inverse relationship to ridership. As home values increase, ridership decreases by more than 5%. This describes the fact that lower income levels, corresponding with people that rent rather than being able to afford to own their homes, are more likely to take public transport. Many people have studied and shown the relationships of higher wealth and lower public transport use, of which, home ownership is one indicator (Boarnet, Bostic, Williams, Santiago-Bartolomei and Rodnyansky, 2017; Boarnet, Hong and Santiago-Bartolomei, 2017; Farber et al., 2014; Pasha et al., 2016).

Of course, beyond the built environment and its connections are the people who decide for whatever reason to take public transport. Demographic attributes that affect ridership and should be considered when choosing the location of new lines and stations. Areas with higher numbers of individuals below the poverty line have a positive impact on ridership (Dieleman and Guillaume, 2002; Fu and Juan, 2015; Gong and Jin, 2014). Lower-income people, even in the low-cost system of Los Angeles, are more likely to take public transport.

5.2.1.4 Architecture, Design or Technology

This model tested whether the station model or configuration had an impact on ridership. A super hub, or transfer hub, with accompanying retail accounts for 7% of ridership. The system type in Los Angeles, faster underground heavy rail versus the slower light rail, with no street intersections, accounting for 1% in ridership. These mixed-use hubs can be destinations in themselves. Urban design specifics such as access and egress have been identified as more effective than efficiency (Boarnet et al., 2013). Spatial configuration has also been related to ridership (Metz, 2013). Combinations of urban design, access and transport have also been effective at raising ridership (Boarnet, Giuliano, Hou and Shin, 2017). Speed of line has shown increases in user choices of public transport (Wan et al., 2016).

5.3 Summary

These results show the specific importance of station design, from speed to lack of intersections as well as location important factors such as low-income residents and population density. The number of rail lines, or destination possibilities, a station has, contributed significantly to ridership and suggests more transfers and complexity be built into the system. These design factors and location demographics should be considered if cities and transport agencies want the most return on social, economic and environmental benefits. Furthermore, these outcomes are the independent contributions of the variables because they are isolated. Outcomes of variables on ridership are likely to be larger in aggregate as they affect each other (Field, 2009). This analysis explains 35% of station passenger rail ridership from these cases within this statistical model. In aggregate these tests would show more influence on ridership than 35% (Cervero and Guerra, 2011; Ewing and Hamidi, 2014; Harding et al., 2013).

The outcomes of this analysis provides insight into where new transport stations should be placed, in particular in dense areas, in low income areas and in areas with complex provision of public transport. The design of new stations should be aware that speed of system, the station configuration and the accessibility of transfers or connection options at stations are part of ridership number returns. Furthermore, there should be an ever-present awareness in transport planning, whether located in developed areas or requiring new surrounding development, of the inverse relationship between wealth and public transport use as well as the potential of new rail stations to push out local low-income residents that were originally meant to be served.

Statistical analysis of United States Census data reveals many things about demographics and their travel modes yet, provides very little insight into the aesthetic qualities of the pedestrian experience (Ksiqzkiewicz, 2012). Census data available is limited to counted people, their travel patterns and certain attributes such as income but these don’t say much about their lived experience and quality of life. This quantitative method of inquiry reports quantitative or numerical results that must still be oriented in context or judgment of quality (Clifton and Handy, 2001). Attracting users is the key to passenger rail success and benefit returns, therefore these relationships should be holistically and rigorously studied and supported through efforts to improve the quality of experience for users because this experience translates to transport use, fare returns and environmental benefits (Frank et al., 2016). Further understanding of station dynamics requires a qualitative and more personal attempt at investigation of the relationship between place, users and public transport ridership (Frank et al., 2016; Ksiqzkiewicz, 2012; Lucas, 2013; Mars et al., 2016). The next chapter proposes a strategy for investigating place including urban design and environmental details that affect users through site mapping. This site survey is then quantified to be incorporated in a statistical analysis.

6 Place Site Analysis Los Angeles

The statistical analysis has provided certain types of results on the relationships of neighbourhood attributes on passenger rail ridership. The attributes that this phase of research has focused on are of a certain scale that describes how groups of variables act and how large groups of people use passenger rail. This scale of research does not tell us about the more detailed or fine-grained attributes of the built environment and how at the smaller scale, urban design elements may affect user experience and mode choice. Observation techniques can be used to fill gaps left by statistical methods and reveal aspects of quality (Bakogiannis, 2014; Clifton and Handy, 2001; Ksiqzkiewicz, 2012; Lucas, 2013; Mars et al., 2016). The next steps of research involved a site analysis tool to look into the urban experience for users and see if that has any impact of user choice of passenger rail (Hickman et al., 2015). The place experience considered in this thesis involves urban design and environment components, such as pedestrian accessibility, the comfort of the station environment, social aspects, a land use mixture, connections to other modes, and the cleanliness and human centricity of the built realm. With these concerns for the individual in mind, the Los Angeles rail system was explored as a user and a site survey was developed from urban research precedents to explore a smaller sample of 31 final stations in more detail.

A site analysis using a survey inspired by William H. Whyte's classical urban studies survey of places with updates to incorporate an assessment of the environment and liveability of stations in Los Angeles (W. H. Whyte, 1980). This site analysis was complemented with satellite mapping and mapping using graphic information systems portals from the municipality. Thirty-one discrete passenger rail stations were surveyed in Los Angeles through the direct observation of the experiential factors of station areas including pedestrian access and amenities, environmental comfort, social attributes, land use mixture, the ease of interaction of modes and the quality of the built environment. These categories were informed by other recent work in the field that uses similar categories to study the quality and comfort in the built environment (Frank et al., 2015; Pijawka and Gromulat, 2012; Redman et al., 2013; Zhou et al., 2017). These results were quantified by category and combined as a total of urban design quality for comparison with ridership to understand how urban quality and ridership are related. This place site analysis shows how experience research provides its own conclusions while complimenting statistical methods. The results are discussed in this chapter followed by a comparison with ridership numbers.

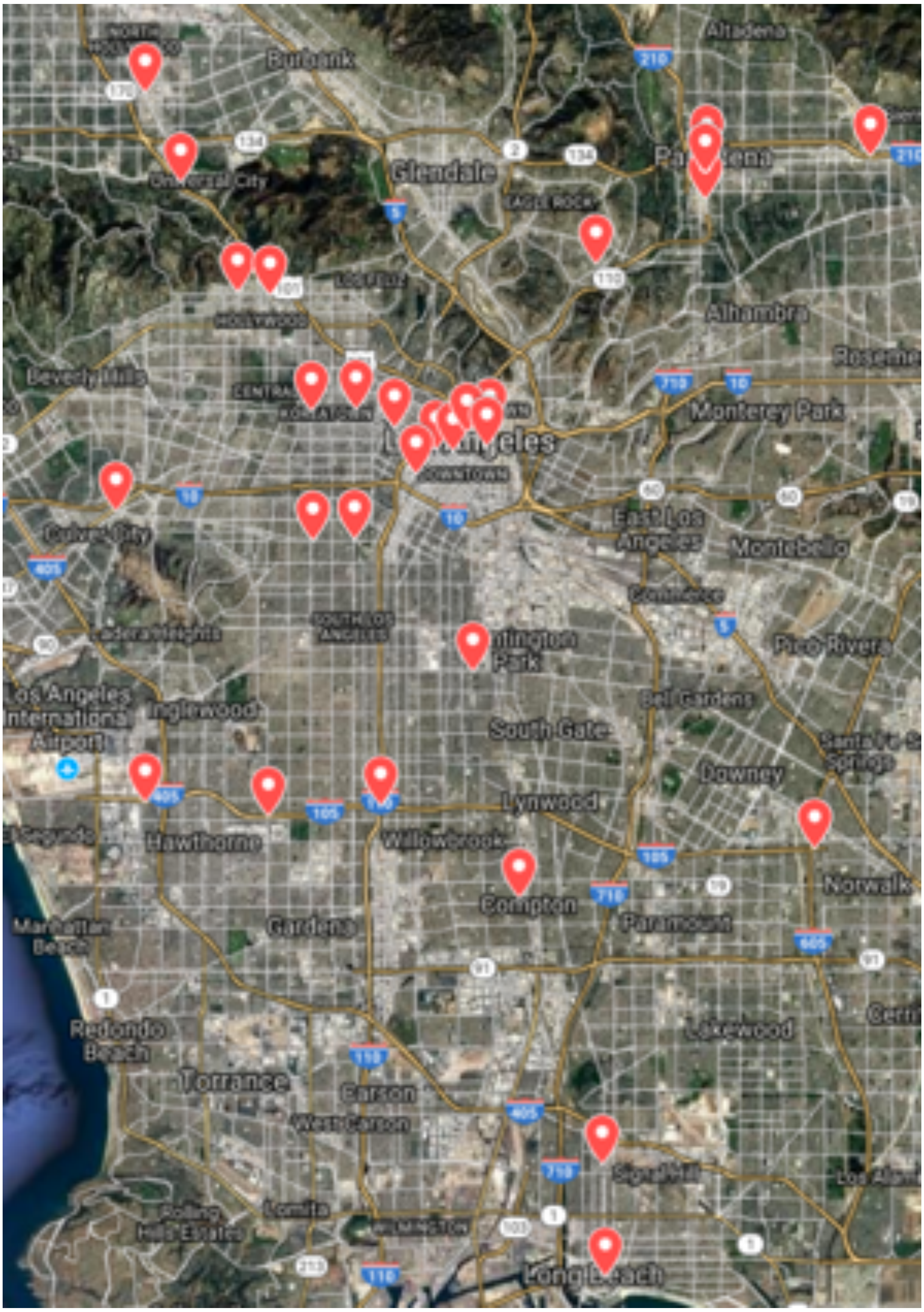

Figure 25. The passenger rail stations surveyed in Los Angeles are shown with red pins (adapted from Google Maps, 2018).

Overall Los Angeles returned decent results in urban quality because of the over median scores in pedestrian quality near stations, social aspects near stations and the offerings of the surrounding land use mix. The interaction of modes and the quality of the surrounding built environment were all at slightly above median. The environmental comfort score was the only result that was slightly below median. However, above median still leaves much room for improvement especially when comparing these station areas with international comparisons incorporated later in this thesis. This place analysis is still useful to see which station areas need investment or improvement and to audit the system's current state. Other recent studies have focuses on walkability and comfort as integral to the pedestrian and user experience of passenger rail (Van Oort et al., 2015; Pijawka and Gromulat, 2012; Redman et al., 2013; Zhou et al., 2017).

Some of the highest results from the entirety of the urban quality site survey were regarding the smooth ground surface for pedestrians, the amount of residential nearby, the visibility of connecting stops for bus connections, cleanliness, the feeling of safety and other people being present. Other issues that were not well provided for were the ease of use for the elderly and children, an unpleasant waiting space and large roads disproportionate to sidewalks. Environmental issues were complicated in Los Angeles with plenty of sunlight, some plantings and trees, yet still the appearance of inadequate shade or shelter.

A few general conclusions came from the site survey of urban quality. The first is that the station areas are generally of a fairly high quality presumably because of the newness of the train system, the amount of investment, including direct investment into the area with new transit-oriented development. The second is the quality of the urban realm that is required for fire and life safety as well as for the Americans with Disabilities Act, which required accessible and smooth pathways for disabled people. Along with the many building requirements for health, safety and access is a general atmosphere of creative and eye-catching architecture.

Quality continues to be high through periphery areas such as the Pasadena stations to the northeast, but these also are well designed and located at smaller city centres of agglomeration. The southern belt of Los Angeles tends to be more of an urban extension condition and quality is intermittent with a rise in central Long Beach. New extensions through the northwest gap will likely be of high quality and located at centres of historic and employment agglomeration. Also, these areas are fairly wealthy and dense.

The next steps compare these urban quality scores of station areas in Los Angeles with ridership data from the Los Angeles County Metropolitan Transportation Authority. Numbers of boarding and alighting were combined for a total rider activity at stations.

6.1 Passenger Rail Ridership in Los Angeles

The high ridership hubs come from the underground lines and the central high-density population of the City of Los Angeles. The financial hub at 7th street and the systems' hub at Union Station have ridership numbers that are far larger than the other stations in the system. At first glance, the major hubs have a slight decrease according to the urban quality survey but still have substantial urban quality amenities. The highest ridership cases from each line were surveyed along with a few novelty cases for a diverse sample of 31 stations that can be compared with ridership. These ridership figures do not include transfers within the same station. Transfers within the station are also within the turn styles and data capture of that information is not available. Speed, efficiency and comfort have been studied and determined to be the most important factors in public transport ridership (Van Oort et al., 2015). Furthermore, accessibility, composed of pedestrian access and egress, are crucial to increasing ridership (Rahaman et al., 2016).

Clusters of ridership activity are apparent from mapping ridership including a central cluster around 7th Street Station, a cluster around Hollywood, a cluster through Pasadena and some distributed high ridership through central Los Angeles south of the historic centre. Along with Union Station and 7th Street station, the stations with transfer connections, Willowbrook and North Hollywood are amongst the highest ridership followed by the Wilshire and Vermont station that is a terminal station in central Los Angeles.

Of these highest performing stations there is a dramatic peak at the central business district stop of 7th Street with most ridership concentrated roughly around the centre with some peculiar lows, such as Little Tokyo which is a central station, and some highs such as the transfer station of Willowbrook at the end of the underground line and transfer station of North Hollywood. Dense areas to the west along the purple line might also be peculiarly low despite residential and business concentrations. Land use types, including employment areas, have been shown in other research affect passenger rail ridership and offered as an area for further study (Hu et al., 2016). The mixture of land uses has been identified as a strong predictor of travel behaviour (Hu et al., 2016; Leck, 2006).

These preliminary conclusions correspond with what was found in the literature review, that central business districts or employment centres, density, mixed-use and retail offerings correspond with higher ridership (Boarnet et al., 2013; Cervero and Kockelman, 1997; Cervero and Landis, 1997; Ford, 1998; Guerra and Cervero, 2010; Handy et al., 2005; Lee and Senior, 2013; Zegras, 2004).

6.2 Case Studies in Los Angeles

6.2.1 7th Street/Metro Center

The 7th Street station is the most used station in Los Angeles. This is an underground type with multiple exits. The station is an end station for the Blue Line and the Expo Line light rail lines while the Red Line and Purple Line heavy rail systems run through to Union Station. The area around the 7th Street Station, by ZIP Code, has a population of 23,719 people and 1,877 businesses (U.S. Census Bureau, 2014). The household residential density per acre is 41.41 (U.S. Census Bureau, 2014). The wealth of the area is very low with median household income at 21,009 United States dollars per year and nearly 52% of the population living under the poverty line

(U.S. Census Bureau, 2014). Owner occupied housing is far less than renter occupied housing (U.S. Census Bureau, 2014). The station area does not offer for connecting modes through auto or bicycle parking because this is a dense area. There is access to buses nearby and other rail lines because this is one of the major transfer stations in Los Angeles. Approximately, 37.4% of people in the area take public transport to work and 8.5% walked to work (U.S. Census Bureau, 2014). These demographic or place characteristics paint a picture that explains ridership in combination with design elements, like underground type and mixed-use urbanism.

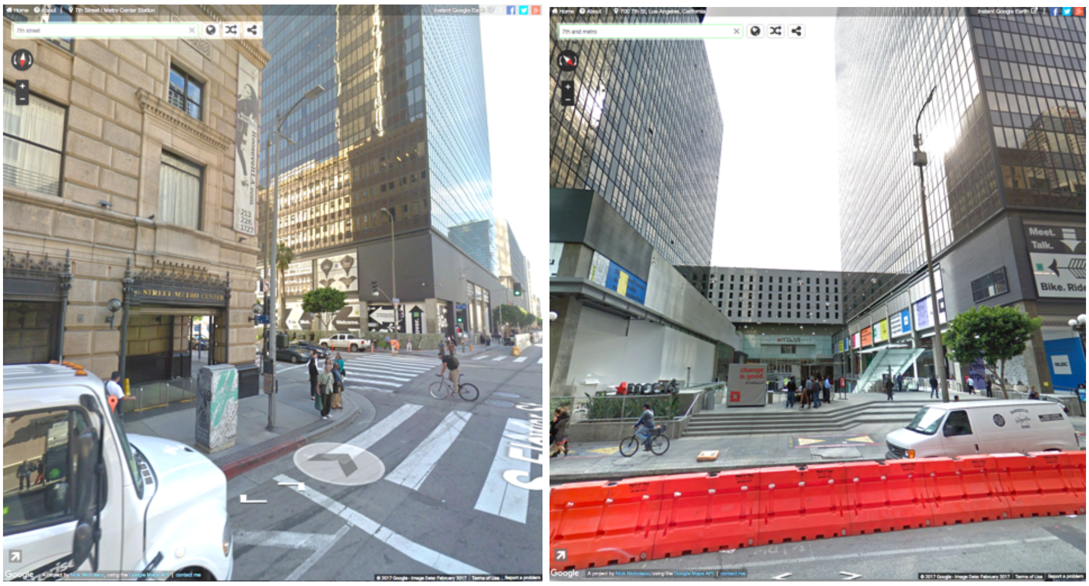

Figure 26. Shows the entry portals of the 7th Street station, under the stone building on the left and down a stairway in the shopping centre on the right (after Nicholaou, n.d. from Google Earth, 2017).

6.2.2 Union Station

Union Station is the only hauptbahnhof or hub style station with interior retail and transfer lines to commuter and regional rail in addition to the LA Metro lines. The population density per acre is 20 while the household density is 11.79 per acre (U.S. Census Bureau, 2014). The population of this ZIP Code is 30,029 and the number of businesses is 1,267 (U.S. Census Bureau, 2014). The wealth indicators of the area include a median income of 29,492 U.S. dollars per year, which is towards the lower side of cases studied in Los Angeles (U.S. Census Bureau, 2014). However, owner occupied housing is still greater than renter occupied housing. Structured to be a place of connecting modes, rail transfer opportunities are numerous, there are also large amounts of paid parking and bicycle parking. Census data does not really show the flaws this station might have, including the insular nature of the superstation, the location is a long walking distance to the financial centre of Los Angeles and monumental scale of surrounding streets. Still, this is the second highest performing station in terms of ridership due to transport planning.

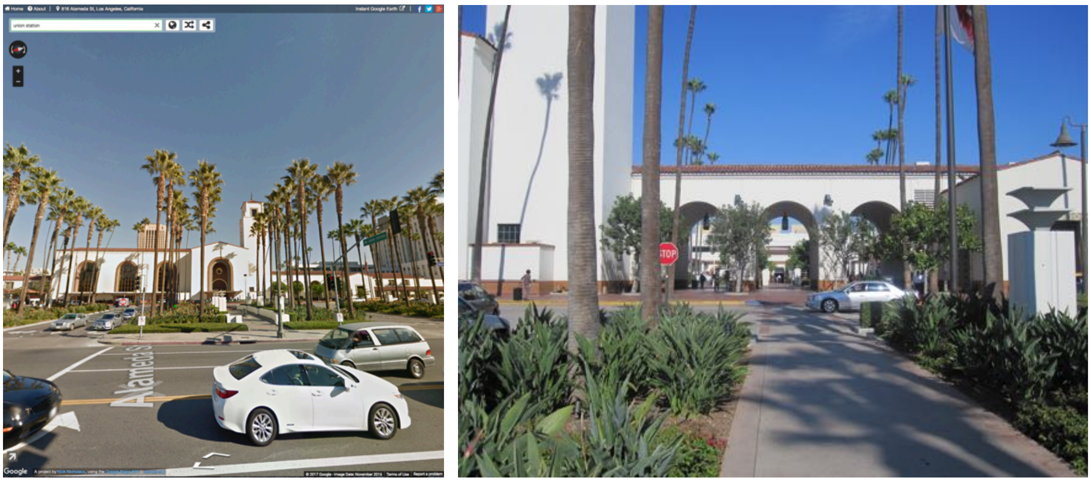

Figure 27. Union Station exterior. Restaurants and shops are in the concourse. Seating areas are in the courtyards (left image after Nicholaou, n.d. from Google Earth, 2017).

6.2.3 Compton Station

Other novel stations worth presenting are Compton station and the central Hollywood stations Hollywood and Highland, and Hollywood and Vine. Compton station takes advantage of a suburban condition in between a strip mall and a city hall. A large grocery store with parking and drive through restaurants, and a municipal centre, are now in walking distance to the passenger rail station. The Compton station half-mile area has a low density at 7.39 households per acre and 21.3 residents per acre as can be seen from Figure 23 (U.S. Census Bureau, 2014). The number of businesses is lower than Union Station or 7th Street station with 713 businesses yet the population is higher with 50,222 residents in 2014 (U.S. Census Bureau, 2014). Compton station offers a different picture of rail stations because it is a case of transport planning in a largely residential area, with density challenges. The wealth indicators might also be a challenge for ridership, with the median household income at 45,744 U.S. dollars per year and more owner-occupied housing than renter occupied housing. This median income places Compton in the top third of station areas surveyed in Los Angeles for wealth. The percentage of people that took public transport to work is in the bottom third of cases studied in Los Angeles. Furthermore, there is limited bicycle parking and no paid parking for the LA Metro station.

Figure 28. Compton station shows a solution to suburban station placement by being located next to a strip mall with a grocery store that was designed for auto users is now within walking distance to the train.

6.2.4 Hollywood and Highland Station With Hollywood and Vine Station

Figure 29. Hollywood and Highland tourist area station, on the Red Line underground line.

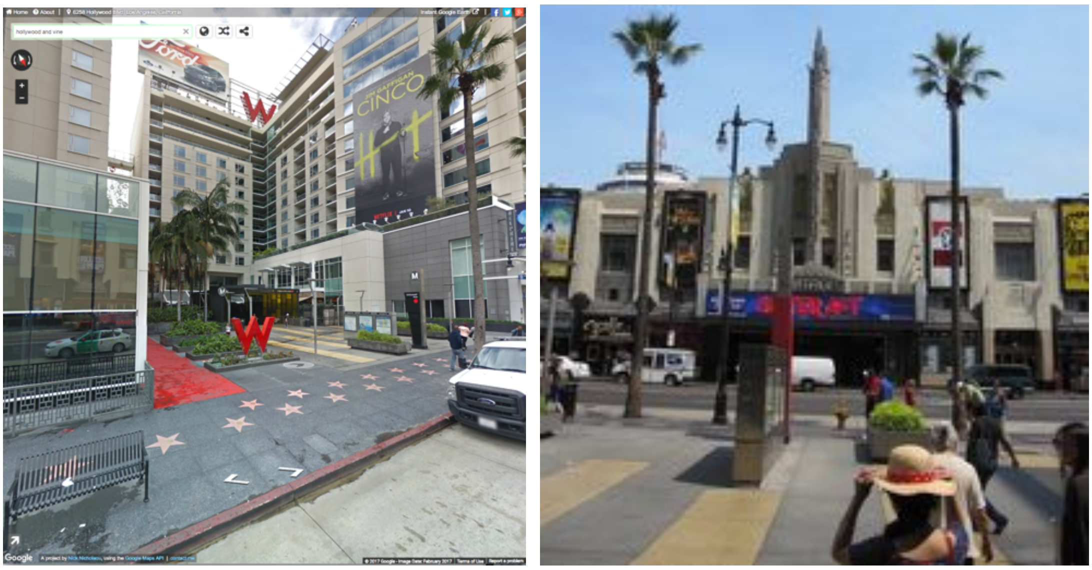

Figure 30. Hollywood and Vine Red Line underground train portal beyond the red w in the hotel courtyard (left image after Nicholaou, n.d. from Google Earth, 2017).

These two Hollywood stations are examples of stations on an underground line, with mixed-use and tourist centre areas. These are busy areas after redevelopment efforts and new transit-oriented developments including a large amount of retail space. The Hollywood stations along with others in similar contexts in downtown Los Angeles with strong urban attributes show that ridership and urban quality may coexist. These stations are also an argument that the utilitarian stations in the middle of an elevated freeway, while they may have high ridership, are not necessary and are a lost opportunity for better quality transit environments and the return of many associated benefits.

Hollywood and Highland station and Hollywood and Vine station are very similar in densities and population but Hollywood and Highland has 606 more businesses than the Hollywood and Vine station area that has 907 businesses. Hollywood and Highland station area has more activity than Hollywood and Vine. Hollywood and Highland has an area population density of 32 persons per acre, with a household density per acre of 21.69, a total of 1,513 business and a population of 29,994 (U.S. Census Bureau, 2014). Hollywood and Vine's population density is higher at 26.4 persons per acre while household density and population are slightly lower than Hollywood and Highland (U.S. Census Bureau, 2014). These station areas are similar, with Hollywood and Highland's area having more density, more businesses, a larger population by less than one percentage and a lower median income by less than one percentage (U.S. Census Bureau, 2014). While owner occupied housing and renter occupied housing are about even at Hollywood and Vine, renter occupied housing at Hollywood and Highland is about double owner-occupied housing. Hollywood and Highland has a lower percentage of those that take public transport to work at 16.6% versus Hollywood and Vine's 22.7% (U.S. Census Bureau, 2014). These two similar stations offer the potential for a comparative study that can determine the nuances of passenger rail use and fine-tune ridership numbers. From these indicators the differences in attributes might account for the difference in passenger rail use. Hollywood and Highland's ridership is much higher and the indicators here suggest that Hollywood and Vine's ridership should be higher, however Hollywood and Highland is a major tourist centre. This type of tourist travel or destination draw is not accounted for in quantitative ridership data, and cannot be derived from U.S. Census data that predominantly tracks travel to work (U.S. Census Bureau, 2014). Land use identifications or zones don't necessarily account for destination attraction, for example being categorized by commercial or office rather than user.

6.2.5 Willowbrook Rosa Parks Station

Willowbrook Rosa Parks station, has high ridership despite the monumental station design. Willowbrook is on the low side of densities in Los Angeles station areas, with 19.7 people per acre and 6.95 houses per acre (U.S. Census Bureau, 2014).

Figure 31. Willowbrook Rosa Parks station shows its inhospitable and monumental scale. The Green Line station is above on the freeway and the Blue Line station is at grade (top left and right after Nicholaou, n.d. from Google Earth, 2017).

This station has three names for some reason, Willowbrook or Imperial after the streets it abuts or Rosa Parks station after the civil right activist but is usually referred to in data sources as some combination of these names. The number of businesses is also low at 209 while the population is fairly high at 42,470 (U.S. Census Bureau, 2014). Median income is about the same as the Hollywood and Vine area at 33,678 United States dollars per year (U.S. Census Bureau, 2014). However, despite the median income of the area, renter occupied housing at 5,506 units outstrips owner occupied housing at 3,923 units (U.S. Census Bureau, 2014). Those nearby that took public transport to work is roughly in the middle of Los Angeles cases at 10.5% (U.S. Census Bureau, 2014). Free parking is fairly plentiful with 231 spaces yet the earlier statistical analysis has not found a connection between free parking and ridership, unlike paid parking and ridership. Other studies have found that free parking is used for other purposes (Meek et al., 2011; Mingardo 2013; Vijayakumar 2011).

6.2.6 Harbor Freeway Station

Harbor Freeway has the absolute worst results from the urban design site survey. The surrounding area cannot be seen because of the monumental scale of the freeway intersection. Household density is low at 6.82 per acre and population density middling at 17.78 (U.S. Census Bureau, 2014). Population is also middling at 22,409 however, the number of businesses is large at 2,328. Despite this number of business, the area appears predominantly residential (Elkind et al., 2015). Median household income is very high at 72,0913 U.S. dollars per year. Similar to Willowbrook station, high median income does not seem to relate to higher home ownership with renters being the dominant residents at 8,151 and owner-occupied housing at 3,606 units (U.S. Census Bureau, 2014). Home ownership may be out of reach financially for residents. Large numbers of free parking is available at 253 spaces and there is some bicycle parking. However, 3% of residents take public transport to work. That does not account for the high trip numbers, 1,564,566.00 trips in 2013, at this station. Perhaps, riders are commuting by a connecting mode, or driving, from other areas to board their train at Harbor Freeway Station. This is one of the few transfer stations in Los Angeles. It may be possible to increase ridership a bit by making more of a design effort to connect to the community but altering the underlying freeway interchange seems impossible.

Figure 32. Harbor Freeway station shows its inhospitable and monumental scale. The Green Line station is above on the freeway and the Silver Line bus rapid transit station is at grade in the middle of a freeway.

6.3 Comparing Place with Passenger Rail Ridership in Los Angeles

Compared with the urban design quality survey, the highest ridership stations do well but are not amongst the best in terms of urban quality defined by the site survey. The highest ridership station, 7th Street, is located in a financial and retail centre that is mixed-use with a historical architecture context. The Union Station transport hub has been planned with restaurants, some housing and pedestrian plazas. However, ridership and investment may be related and quality and investment are related but ridership and quality are not necessarily related. The 1st Street station in Long Beach has several attributes that would suggest high ridership. It is a station in a mixed-use office, retail, conference and tourist centre close to the beach. The urban quality survey score is high yet the ridership is actually the lowest of this sample. Del Mar station in Pasadena is a planned and designed mixed-used station with housing above a quiet retail plaza. The station is of good design quality and is fairly close to the shopping and office district of downtown Pasadena. Both of these stations are on the slower light rail lines that may explain some of the low ridership. The main components brought up by these results are the matching of ridership with speed, mixed uses and urban quality for the pedestrian (Badland et al., 2017; Cascetta and CartenÏ, 2013; Hu et al., 2016).

The average place survey score for Los Angeles was 26.1 and the average passenger rail ridership is 4,061,570 trips per year. The median place survey score is a bit higher at 30 meaning that more stations were toward the higher end of place quality while the ridership median was lower, by far, at 2,349,537 meaning that a few very high performing stations were skewing the results. This underscores the fact that the interchange hubs, 7th Street Station and Union Station, are much higher performing in ridership than the others and might be worthy of investigating as part of a different cohort and for different discoveries. They are different types based on their behaviour or performance.

These samples show a trend in urban quality and ridership in Los Angeles. They also show that while many high ridership stations have high urban quality, due to transit-oriented development or by being located in mixed-use areas, there are some outliers such as Willowbrook transfer station that is located within a freeway, extremely inhospitable to human or commercial activity and yet has high ridership likely due to being a transfer station. At the extreme upper end of passenger rail ridership in Los Angeles, the urban quality of stations suffers. However, it can be said that mixed uses and high-quality pedestrian environments are, for the most part, not mutually exclusive with high ridership.

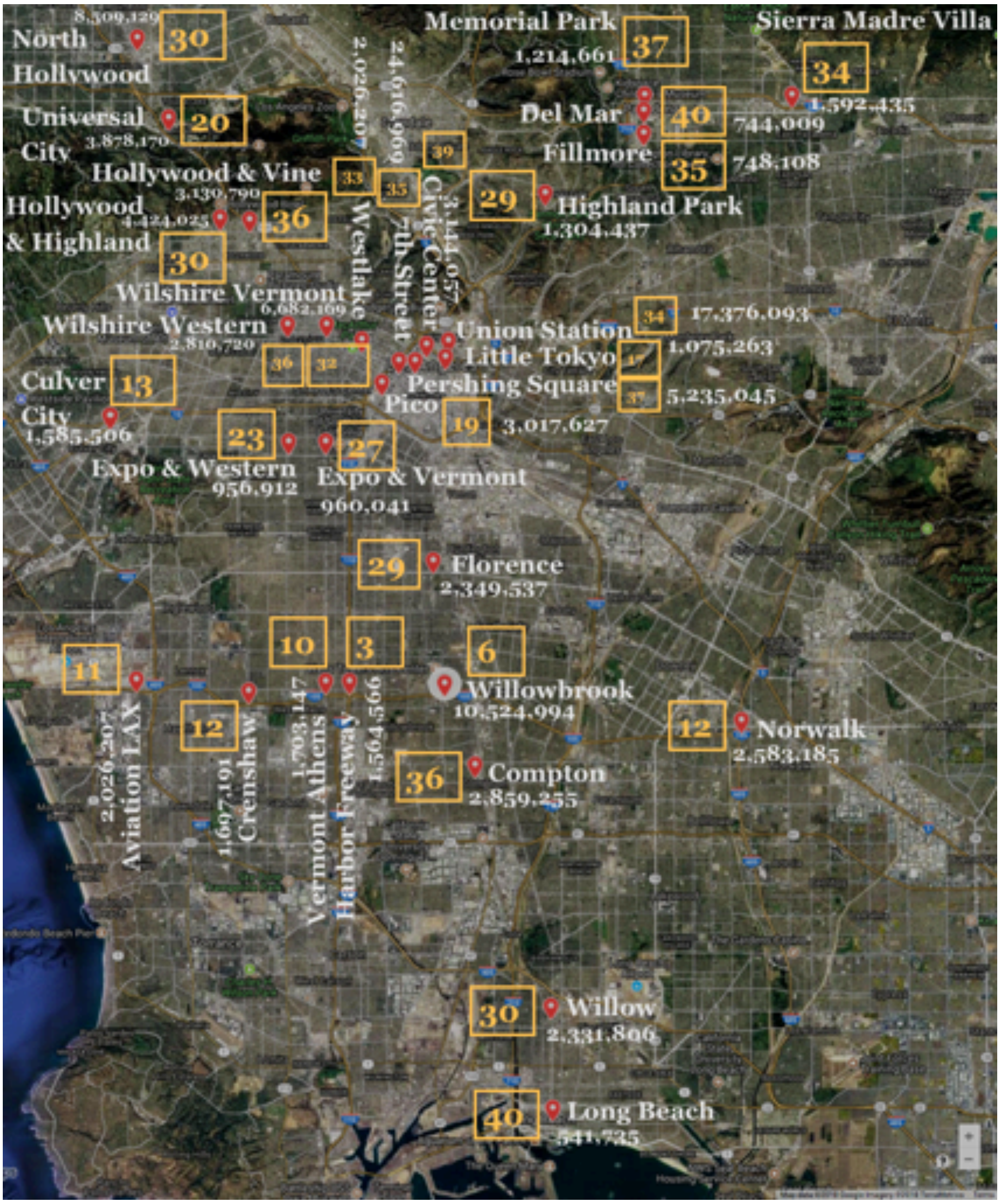

Figure 33. The place quality score for pedestrian realm by passenger rail ridership at stations (adapted from Google Maps, 2018).

Table 9. Stations sorted by ridership totals and then place quality survey score.

7th Street and Metro*	35	**24,616,969**	Del Mar	**40**	744,009
Union Station*	34	**17,376,093**	1st Street Long Beach	**40**	541,735
Willowbrook Rosa Parks / Imperial and Wilmington*	6	**10,524,994**	Civic Center*	**39**	3,144,057
North Hollywood**	30	**8,509,129**	Pershing Square*	**37**	5,235,045
Wilshire and Vermont *	32	**6,682,169**	Memorial Park	**37**	1,214,661
Pershing Square*	37	**5,235,045**	Hollywood and Vine	**36**	3,130,790
Westlake MacArthur Park*	33	**4,720,881**	Compton	**36**	2,859,255
Hollywood and Highland	30	**4,424,025**	Wilshire and Western	**36**	2,810,720
Universal City	20	**3,878,170**	7th Street and Metro	**35**	24,616,969
Civic Center*	39	**3,144,057**	Filmore	**35**	748,108
Hollywood and Vine	36	**3,130,790**	Union Station*	**34**	17,376,093
Pico*	19	**3,017,627**	Sierra Madre Villa	**34**	1,592,435
Compton	36	**2,859,255**	Westlake MacArthur Park*	**33**	4,720,881
Wilshire and Western	36	**2,810,720**	Wilshire and Vermont	**32**	6,682,169
Norwalk	12	**2,583,185**	North Hollywood**	**30**	8,509,129
Florence	29	**2,349,537**	Hollywood and Highland	**30**	4,424,025
Willow	30	**2,331,806**	Willow	**30**	2,331,806
Aviation LAX	11	**2,026,207**	Florence	**29**	2,349,537
Vermont / Athens / Green Line	10	**1,703,147**	Highland Park	**29**	1,304,437
Crenshaw	12	**1,697,191**	Expo and Vermont	**27**	960,041
Sierra Madre Villa	34	**1,592,435**	Expo and Western	**23**	956,912
Culver City	13	**1,585,506**	Universal City	**20**	3,878,170
Harbor Freeway**	3	**1,564,566**	Pico*	**19**	3,017,627
Highland Park	29	**1,304,437**	Little Tokyo	**17**	1,075,263
Memorial Park	37	**1,214,661**	Culver City	**13**	1,585,506
Little Tokyo	17	**1,075,263**	Norwalk	**12**	2,583,185
Expo and Vermont	27	**960,041**	Crenshaw	**12**	1,697,191
Expo and Western	23	**956,912**	Aviation LAX	**11**	2,026,207
Fillmore	35	**748,108**	Vermont / Athens / Green Line	**10**	1,703,147
Del Mar	40	**744,009**	Willowbrook Rosa Parks / Imperial and Wilmington*	**6**	10,524,994
1st Street Long Beach	40	**541,735**	Harbor Freeway**	**3**	1,564,566
*Rail connection available **Bus rapid transit connection available					

The urban quality site survey score correlates with higher ridership, with some exceptions. Perceptions in urban quality have been found to exceed service and frequency for attracting car users to use public transport (Redman et al., 2013). However, a high-quality score does not ensure high ridership by any means as shown by Del Mar and Long Beach stations. The highest ridership stations Union Station and 7th Street are roughly amongst the top third of stations in terms of quality. A side by side comparison shows the urban design quality in Los Angeles is spread because of diverse strategies that range from lines amongst elevated freeways, to those within urban conditions, to those with heavily invested transit-oriented developments. Union Station and 7th Street Station are also of interest because they have the highest ridership with two different strategies, namely a well-built station versus a well-placed station respectively. 7th Street gains its urban quality from a careful location in the centre of the mixed-use downtown financial centre and gains its ridership from its attribute as a major employment centre and transfer station. Union Station is the official LA Metro hub and rail transport hub strategy with inherent urban amenities. However, Union Station is interior facing and within in a less walkable area. Otherwise ridership across the stations in Los Angeles is more consistent than quality but Union Station and 7th Street Station show that quality and intense ridership do not have to be mutually exclusive. Given the number of benefits that have been found to accompanying high quality mixed-use walkable areas, and their connection to higher ridership, it is important to develop these characteristics when implementing new public transport (Boarnet et al., 2016; Cass and Faulconbridge, 2016; Hong et al., 2016; Jabareen, 2007; Spears et al., 2017).

The following charts show the results from the urban quality survey against the ridership numbers of all 31 stations surveyed in this sample. The following figure shows a slight rise in ridership as quality goes up and that a relationship between the two may be evident.

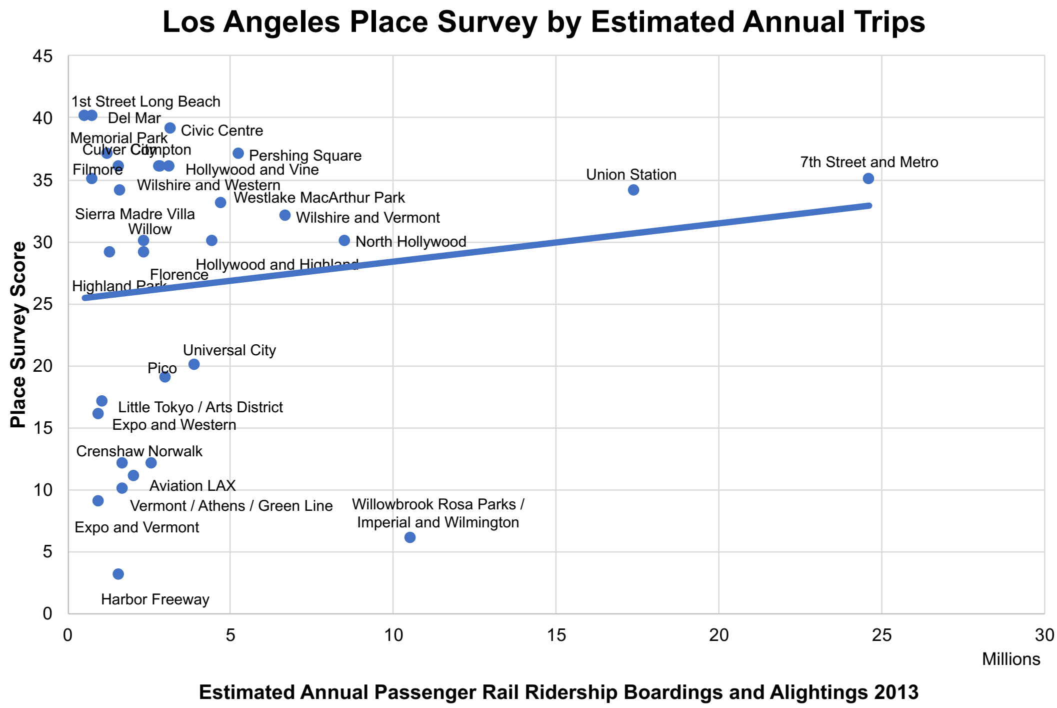

Figure 34. Shows a positive slope in Los Angeles between place quality and passenger rail ridership.

Breaking down the chart into the six categorical metrics, pedestrian access, the environment and comfort and social aspects show a negative relationship with ridership shown in Figure 35. Social aspects have been claimed to be a benefit of public transport projects and social benefits have been found in other studies (Ornetzeder et al., 2008). However, this is not the case from these Los Angeles results that show public transport ridership have a slightly negative relationship with social life. The three categories that most affect human comfort show at least a slight decline in relation to ridership.

The interaction of modes understandably shows a positive relationship with ridership following the conclusions from many other studies on mode connections and the interaction of sustainable modes (Badland et al., 2017; Boulange et al., 2017; Cass and Faulconbridge, 2016). The built environment, and the surrounding land uses mixture metrics both show positive relationships with ridership. Land use mix has been shown in other studies to support public transport ridership (Gong and Jin, 2014; Handy et al., 2005).

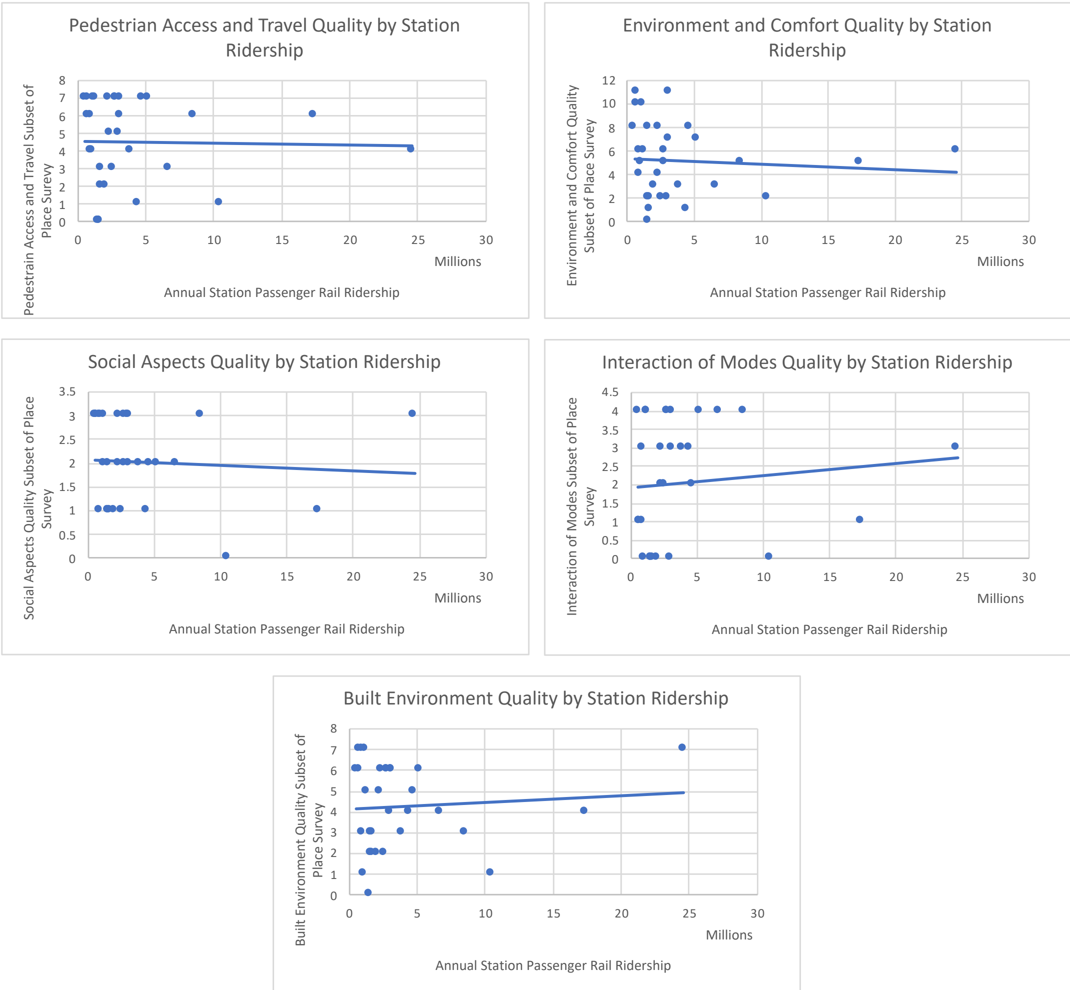

Figure 35. The five subsets of the place quality survey by passenger rail station ridership.

From the urban quality study, what do high ridership stations and high urban quality stations have in common and where might there be overlap and opportunities? The top five highest ridership stations in Los Angeles, 7th Street, Union Station, Willowbrook, North Hollywood and, Wilshire and Vermont station are all stations with transfer and multiple line opportunities. These are where lines, and the city itself, connect. Their urban conditions and development strategies vary.

The stations with the highest quality urban environment according to the survey seem to have no relation to ridership. For example, 1st Street in Long Beach and Del Mar station have the highest place quality scores yet some of the lowest ridership of this cohort. These high achieving urban quality stations do so by having nearly impeccable pedestrian access scores, with a 91.43% result of possible in surroundings and land use mix score as well. At the same time, some stations with the worst urban quality, according to the survey, also have very high ridership such as the Willowbrook transfer station that are in the middle of large elevated auto freeways. However, other stations with slightly less urban quality have high ridership numbers and it is shown to be possible from these cases that a high urban quality and comfort for people, does not exclude high ridership.

6.4 Typologies and Operationalisation

Some typologies have been introduced already including the mixed-use transfer hubs 7th Street Station and Union Station. Typologies have been researched in transport planning before but conclusions and their relationships to passenger rail ridership are still obscured (Zemp et al., 2011b). Types of stations or neighbourhoods and their impacts on passenger rail remain broad or vary from place to place, including even stalwart variables like density (Papa and Bertolini, 2015; Zemp et al., 2011b). More research on typologies has been called for, in particular the range and scale of benefits certain typologies may have and the exact benefits that specific types of land use, place or living may convey (Reusser et al., 2008). Typologies can be a means of analysis and potentially a means of operating, of designing the built environment to function in certain ways.

From the previous literature and case study analysis, two main aspects of types are appropriate for investigation, station location and station architectural design (Payton and Hawkes, 2013). A third factor related to design is rarely discussed in terms of typology and that is the technology of the passenger rail, heavy or light rail, which has implications for speed, underground or street level interactions and station architecture.

The statistical and site analysis has identified some categories or types of station areas that perform in certain ways. Transfer stations, heavy rail lines and underground stations are upward performing in ridership in Los Angeles. Place types that are upward performing are lower income areas, denser areas, and station areas amenable to connecting modes, including accommodating taxis and stations with paid parking. End stations or terminal stations are a type of station that had a negative relationship with ridership, while areas unfriendly to the connecting mode of bicycles also were a negative influence on ridership. From the mapping study, the central areas and stations along the heavy rail underground line had higher ridership. The use of types of cities, neighbourhoods or buildings has been discussed often in urban research (Ewing, 1997; Gordon and Richardson, 1999; Hall and Pain, 2006; Jacobs, 1961; Lynch, 1960, 1961, 1972; Marshall, 2005, 2009).

Three typology studies are presented in this chapter, including two analyses of land use compared with station ridership and an analysis on transit-oriented development versus a station location strategy to encourage ridership.

Union Station and 7th Street Station were identified as particular transfer hub or hauptbahnhof types because of their monumental ridership numbers in comparison to the rest of the cases and their mixed-use station architecture. Station neighbourhood typology and station architectural typology are not a fixed relationship, with some common occurrences such as a transfer hub in a mixed-use employment area occurring often, yet in some places such as Harbor Freeway in Los Angeles passengers interchange without any station retail development or connection to the street level.

6.4.1 Station Area Place and Dominant Land Uses in Los Angeles

Dominant station area land use does not appear to be a determining force of passenger rail ridership, shown in Table 10. However, a mixed land use status supporting higher ridership does seem apparent from the urban quality survey of this thesis and from existing literature (Gong and Jin, 2014; Handy et al., 2005). Further research into mixed land uses surrounding high performing stations needs to be done, including research and developing a metric, before further conclusions could be made in Los Angeles. The University of California Berkeley Center for Law, Energy and Environment has done some similar research on grading station areas in California and determining a dominant land use of a station area (Elkind et al., 2015). The results of their research are compared with the urban quality survey of this thesis and ridership numbers acquired from the LA Metro in Tables 10 through 13.

Previously, the statistical analysis noted a positive correlation between the University of California Berkeley's transport station metric and ridership, shown in

Table 4. Factors that make up dominant land use categories have also been related to passenger rail ridership including population and household residential density of the surrounding area. However, the indicators that make up the Berkeley Grading California Rail Transit Station Areas (GCRTSA) survey are focused on macro level issues such as transit use, affordability, general walkability, jobs, greenhouse gas emissions, amongst others, rather than a detailed itemization of the user experience including urban design elements such as sidewalks and shade. Many of the indicators in the GCRTSA study have been covered by the statistical analysis portion of this thesis with similar results shown in Tables 4 and 5.

The GCRTSA and the place site analysis had similar results except for the Harbor Freeway and Willowbrook, which was much lower on the place site analysis due to more human centric in the place quality urban design survey. Some stations lower in the GCRTSA for macro transport issues such as connections were higher due to aspects of the human environment such as Civic Centre, Del Mar and Long Beach station. The differences suggest that user experience and the pedestrian realm of urban elements required a more qualitative approach to yield insights (Bakogiannis, 2014; Clifton and Handy, 2001; Lucas, 2013; Mars et al., 2016).

Table 10. The urban quality score of this thesis by ridership from the LA Metro by the University of California at Berkeley Center for Law, Energy and the Environment's overall neighbourhood score and land use determination, in order of descending ridership (adapted from Elkind et al., 2015).

Station Name	Ridership 2013	UD Quality Survey Score	GCRTSA Score *	GCRTSA Land Use **
7th Street and Metro	**24616969.00**	35.00	79.20	3.00
Union Station	**17376093.00**	34.00	66.00	3.00
Willowbrook Rosa Parks / Imperial and Wilmington	**10524994.00**	6.00	45.80	1.00
North Hollywood	**8509129.00**	30.00	65.40	1.00
Wilshire and Vermont	**6682169.00**	32.00	77.90	2.00
Pershing Square	**5235045.00**	37.00	79.10	3.00
Westlake MacArthur Park	**4720881.00**	33.00	88.20	1.00
Hollywood and Highland	**4424025.00**	30.00	73.20	2.00
Universal City	**3878170.00**	20.00	62.20	2.00
Civic Centre	**3144057.00**	39.00	63.90	2.00
Hollywood and Vine	**3130790.00**	36.00	71.80	2.00
Pico	**3017627.00**	19.00	66.00	3.00
Compton	**2859255.00**	36.00	57.40	1.00
Wilshire and Western	**2810720.00**	36.00	83.20	1.00
Norwalk	**2583185.00**	12.00	40.20	1.00
Florence	**2349537.00**	29.00	60.10	1.00
Willow	**2331806.00**	30.00	40.63	2.00
Aviation LAX	**2026207.00**	11.00	42.90	3.00
Vermont / Athens / Green Line	**1703147.00**	10.00	50.40	1.00
Crenshaw	**1697191.00**	12.00	46.40	2.00
Sierra Madre Villa	**1592435.00**	34.00	45.73	2.00
Harbor Freeway	**1564566.00**	3.00	53.00	1.00
Highland Park	**1304437.00**	29.00	69.50	1.00
Memorial Park	**1214661.00**	37.00	54.13	3.00
Little Tokyo / Arts District	**1075263.00**	17.00	72.00	3.00
Filmore	**748108.00**	35.00	56.83	2.00
Del Mar	**744009.00**	40.00	50.53	3.00
1st Street Long Beach	**541735.00**	40.00	57.13	2.00
GCRTSA Score = Grading California's Rail Transit Station Areas' Grade. * Grade based on metrics of transit use and safety, land use and walkability, policy and real estate market, transit affordability and dependency, and greenhouse gas emissions.				
**GCRTSA Land Use = Grading California's Rail Transit Station Areas' Land Use Determination:		1= Primary Residential	2 = Mixed	3= Primary Employment
Expo and Vermont, Expo and Western and Culver City were not graded for GCRTSA study.				

6.4.2 Land Use by Ridership in Los Angeles

The Grading California's Rail Transit Station Areas (GCRTSA) is a report similar to the research presented in this thesis (Elkind et al., 2015). Station areas were determined to have a primarily residential land use if 33.3% or less were workers, versus residents, between 33.4% and 66.6% of workers relative to residents, and were determined to be primarily an employment area if 33.3% or less were residents. The Los Angeles stations that were site surveyed were put against this land use metric. Only 28 of the 31 stations site analysed were compared with the GCRTSA study because the GCRTSA didn't cover all stations in Los Angeles. From these cases it appears that employment centres have much higher ridership than the other two land uses, corresponding to the academic literature on the subject of employment centres promoting ridership (Cervero, 2002; Cervero and Duncan, 2002; Cervero et al., 2002; Mees, 2010). However, this is a small sample and 7th Street and Union Station have ridership data that far exceeds the other cases, and those two are predominantly employment centre areas. The drivers of major ridership in Los Angeles still appears to be a combination of many variables, with transfer availability of note.

Table 11. Land use determination from the GCRTSA report (after Elkind et al., 2015).

Residential	Less than 33.3% are workers.
Mixed	Between 33.4% to 66.6% are workers.
Employment	66.7% or more are workers.

Table 12. Dominant land uses found in GCRTSA report (after Elkind et al., 2015).

Station Name	GCRTSA Land Use	Ridership 2013
Westlake MacArthur Park	Residential	4720881.00
Wilshire and Western	Residential	2810720.00
Highland Park	Residential	1304437.00
North Hollywood	Residential	8509129.00
Florence	Residential	2349537.00
Compton	Residential	2859255.00
Harbor Freeway	Residential	1564566.00
Vermont / Athens / Green Line	Residential	1703147.00
Willowbrook Rosa Parks / Imperial and Wilmington	Residential	10524994.00
Norwalk	Residential	2583185.00
	Average of 10	**38929851**
Wilshire and Vermont	Mixed	6682169.00
Hollywood and Highland	Mixed	4424025.00
Hollywood and Vine	Mixed	3130790.00
Civic Centre	Mixed	3144057.00
Universal City	Mixed	3878170.00
1st Street Long Beach	Mixed	541735.00
Filmore	Mixed	748108.00
Crenshaw	Mixed	1697191.00
Sierra Madre Villa	Mixed	1592435.00
Willow	Mixed	2331806.00
	Average of 10	**28170486**
7th Street and Metro	Employment	24616969.00
Pershing Square	Employment	5235045.00
Little Tokyo / Arts District	Employment	1075263.00
Union Station	Employment	17376093.00
Pico	Employment	3017627.00
Memorial Park	Employment	1214661.00
Del Mar	Employment	744009.00
Aviation LAX	Employment	2026207.00
	Average of 8	**55305874**

However, these three land uses are not detailed enough to draw sufficient conclusions. With more parsing of land uses the behaviour is more revealed and analysis becomes more detailed. (Badland et al., 2017; Boulange et al., 2017; Ding, 1998). Predominantly residential, employment and a predominantly mixed land use do not reveal proportions of mixture in land uses that may affect ridership. Certain mixtures of employment and residential may encourage ridership while others may correlate with a decline in ridership, and there are likely converse relationships where too much of one or the other declines place quality. Other land uses that are appropriate to study in terms of station area typologies are predominantly tourist destinations, delineating employment between office and commercial, as well as noting specific large destinations such as hospitals or universities that stations are even named after.

Transit-oriented development strategies for stations is compared with a station placement strategy, with little or no transit-oriented development, finding that placement strategies in Los Angeles return more ridership. The stations with transit-oriented development investment do better in urban quality from a site survey and in the GCRTSA's station area quality metric. However, from this sample a well-placed station can have higher ridership than the transit-oriented development stations. Typology or categories seem useful to identify general behaviour and offers a stepping-stone to analysis that is based more on the individual case.

Table 13. Transit-oriented development compared with a non-land use development strategy according to the urban design survey score, ridership and the GCRTSA (Elkind et al., 2015).

	Place Quality Survey Score	Station Ridership 2013	GCRTSA Score
LA Metro Joint Development / Transit-Oriented Development	34 *	4,456,104 *	74 **
Little or No Transport Agency Development / Rail Placement Strategy	27 ***	5,210,131 ***	58 ****
*Average of 10. **Average of 11. ***Average of 7. ****Average of 6.			

6.4.3 Outliers in Los Angeles

Union Station and 7th Street station perform radically different in terms of passenger rail ridership in Los Angeles. Returning to statistical methods reaffirms this. Developing models for statistical analysis often involves cutting outliers like Union Station and 7th Street station because they can skew the results (De Veaux et al., 2009; Field, 2009; Mertler and Vannatta, 2005). One type of outlier can be the stations that have dramatically different ridership than the general case population. Statistical analysis is a different process than other methods because it requires data management to sort like cases with a normal distribution before reliable analysis and claims may be made. This could be one major criticism of statistical methods, that they dismiss outliers, stations that are over performers or under performers. Often in urban planning, changes in the urban status quo are desired such as ameliorating blight and focusing only on the median cases may occlude helpful research findings. In this case, using statistics to identify outliers reveals a passenger rail typology, the super hub mixed-use transfer station. Berlin has stations like these called hauptbahnhofs and of course there are several mixed-use transfer junctions in London.

Figure 36 shows the outliers Union Station and 7th Street that have been discussed and analysed previously. The ridership numbers of 7th Street station far outstrip the rest of the station cases from Los Angeles. There is a rapid change in ridership performance at the high end with the top two stations showing a much more dramatic upward slope in ridership than the trend of stations in Los Angeles. From the ridership numbers there is a 49.5% jump between the 2nd highest ridership earning station, Union Station, and the third highest performing station Willowbrook that changes the trend of the slope. There are other jumps in ridership but none as dramatic as the 49.5% increase between the second highest and third highest. This represents a significant change in scale and a different typology based on station behaviour.

The remaining cases are all under ten million trips at that station per year, or close to it in the case of Willowbrook station. Union Station and 7TH Street are dramatically different in passenger rail performance and this possibly identifies different behaviour of these stations in other ways. There are also some dramatic place results that are much different than the majority of the stations including Harbor Freeway and Willowbrook stations. The noticeable poor quality of the urban realm at Willowbrook has prompted a remodel of the station, under construction at the time of this writing. However, there are major problems in place quality and it is unlikeley a cosmetic remodel has the power to overcome the disadvantages of monumental scale and a passenger rail interchange in the middle of two major multi-lane Los Angeles freeways.

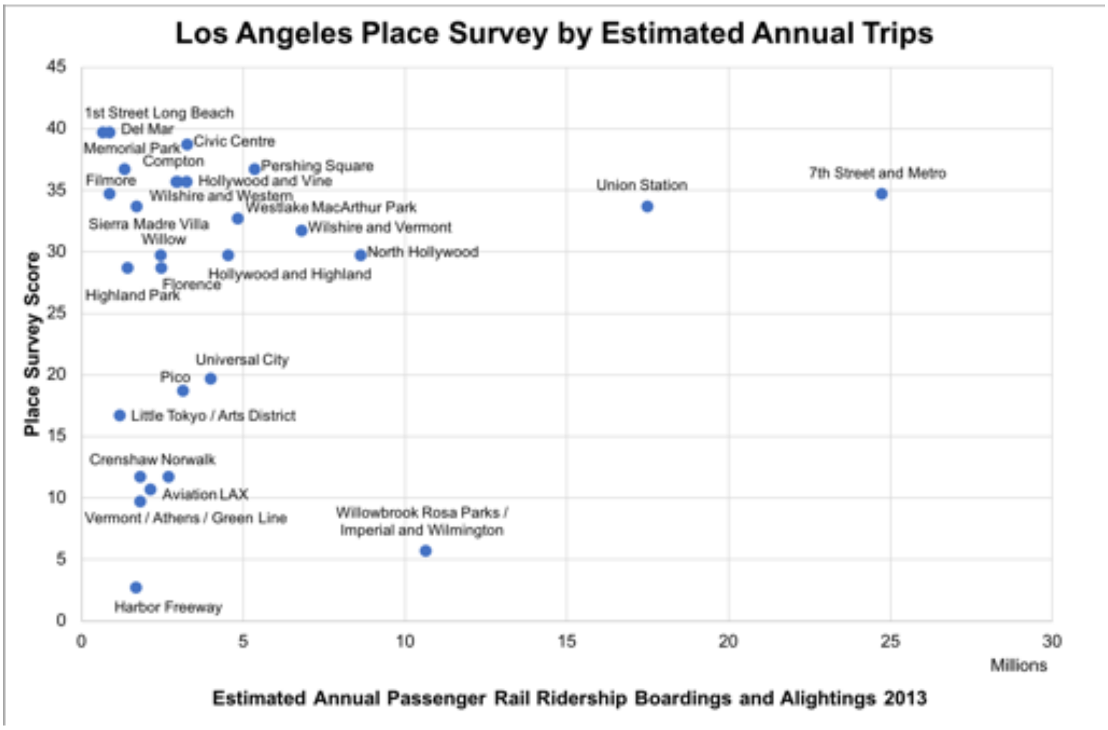

Figure 36. Place quality survey by passenger rail ridership in millions.

6.4.4 Developing Useful Typologies

Typologies of passenger rail stations can be defined in different ways. The following works at an inductive definition of typologies of passenger rail stations through observation similar to Payton and Hawkes previously discussed in 2.3 (Hawkes and Sheridan, 2009; Payton and Hawkes, 2013). From the GCRTSA study we have three main if general types of station areas, residential, mixed and employment. From the statistical analysis we have two stations that behave differently than the rest of the group in Los Angeles, the super hub, the mixed-use central transfer junction. These are a combination approach of station area and station design typologies (Elkind et al., 2015). From the site analysis, a fifth type emerges which is a tourist destination. A sixth type can be identified from mapping and site analysis, the civic or institutional type. The institutional or civic type of station area typically characterized by public space and public employment centres with areas more open to the public than private employment areas. In the following analysis, the civic land use typology includes station areas that are dominantly a hospital, a university or a governmental civic centre. These are often less mixed-use areas than private employment centres might be and also slower to change. Civic areas and tourist areas are interesting in terms of ridership because they have different peak times than other types of employment areas. When a new typology is unapparent, the typologies presented in Table 14 defer to the GCRTSA study (Elkind et al., 2015). Employment centres are capable of being office centres, retail centres or blurring the boundaries with industrial land use designations such as auto shops or distribution. Of course, these categories have overlaps, most areas are actually some sort of mixed condition, but these six types offer a means to begin analysis and operationalization beyond what has previously been done with typologies of passenger rail stations and their areas.

Table 14. A typology list of passenger rail stations and their areas in Los Angeles (adapted from Elkind et al., 2015).

Station Name	Type	Ridership 2013
7th Street and Metro*	Super Hub	24616969
Union Station*	Super Hub	17376093
Willowbrook Rosa Parks / Imperial and Wilmington*	Residential	10524994
North Hollywood***	Residential	8509129
Wilshire and Vermont*	Mixed	6682169
Pershing Square**	Employment	5235045
Westlake MacArthur Park**	Residential	4720881
Hollywood and Highland	Tourist	4424025
Universal City	Mixed	3878170
Civic Centre**	Civic	3144057
Hollywood and Vine	Mixed	3130790
Pico **	Employment	3017627
Compton	Residential	2859255
Wilshire and Western	Residential	2810720
Norwalk	Residential	2583185
Florence	Residential	2349537
Willow	Mixed	2331806
Aviation LAX	Employment	2026207
Vermont / Athens / Green Line	Residential	1703147
Crenshaw	Mixed	1697191
Sierra Madre Villa	Mixed	1592435
Harbor Freeway***	Residential	1564566
Highland Park	Residential	1304437
Memorial Park	Employment	1214661
Little Tokyo / Arts District	Employment	1075263
Filmore	Mixed	748108
Del Mar	Employment	744009
1st Street Long Beach	Mixed	541735

* Transfer Stations.

** Possible to transfer to a parallel line but not necessary until a later station.

*** Transfer to a bus rapid transit line.

From the more detailed list of six typologies in Table 14, the super hubs of Los Angeles are still the highest passenger rail ridership stations. This sample of tourist and civic types is too small to make claims but identifying them is useful in comparison to other civic stations in other cities. Again, the stations where it is possible to transfer to another line are generally the higher performing passenger rail ridership stations. However, from this sample the Harbor Freeway station that has a possible transfer to a bus rapid transit line doesn't have substantially high ridership and is one of the lowest performing stations. Harbor Freeway is a transfer station within the junction of two major freeways disconnected from the street and fairly inhospitable. The tourist centre of Hollywood and Highland is in the upper third of ridership despite not having any rail or bus rapid transit transfers available. Tourist centres are a place of transport planning potential in that they may provide for transfers, mixed uses and still have high place qualities (Harrill, 2016). However, from this sample there is a good mix of land uses by passenger rail ridership with residential, employment and mixed-use station areas performing in a roughly equal fashion. Again, most station areas are somewhat mixed-use. In Figure 37 both super hubs are located in the same area. The map shows a trend of the system being oriented to the downtown employment centre from mixed or residential areas. It is curious in the polycentric city to have a monocentric passenger rail system and it seems obvious that some benefit for ridership returns would come from recognizing the other centres of Los Angeles with transfer hubs, creating a much more complex system as experts suggest would return more riders and benefits (Cervero and Guerra, 2011; Cervero et al., 2017; Guerra and Cervero, 2010).

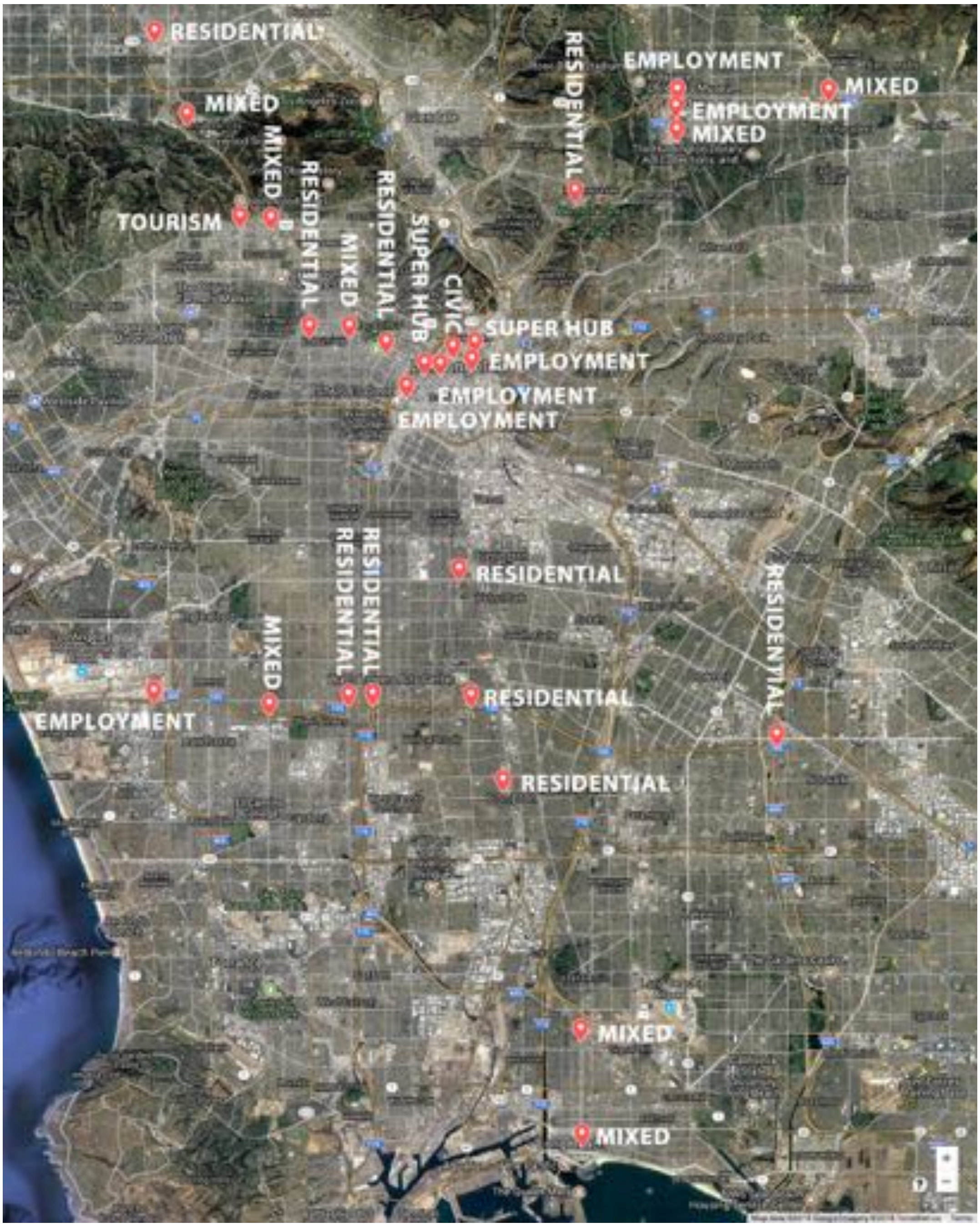

Figure 37. Los Angeles map of the predominant land uses of station areas.

6.5 Summary

The place site survey makes some relevant conclusions regarding the human experience of these station areas, namely that the categories that measure comfort responded negatively to increases in ridership. Pedestrian access, social aspects, the natural environment and comfort all suffered a perceived loss in quality for the higher ridership stations. These include issues of quality for human comfort such as smooth sidewalks, shade, perception of air quality and the appearance of safety. However, access and egress, including proximity of stops have been found to be part of increasing ridership (Tabassum et al., 2017; Wan et al., 2016). Attributes of quality are largely based on user perceptions therefore a user site survey seems appropriate (Redman et al., 2013). Urban planning factors, such as the interaction of modes, the land use mixture and the quality of the built environment all saw correlative increases for higher ridership stations.

These categories and their results are different than what has been determined from the statistical analysis of this thesis and complement the quantitative study. Site analysis shows not only the context, or ingredients, but also the details of urban design and architecture, of shape, form and scale. These types of conclusions offer opportunities for fine-tuning station areas in existing cities. For example, retail opportunities alone would argue against the elevated freeway station conditions of Harbor Freeway and Willowbrook stations. Taking human comfort into consideration would further argue against these monumental transfer stations. While Willowbrook is the third highest ridership station of these cases, the harsh environment is not necessary as Union Station and 7th Street station have more passengers and a much more human high-quality environment. An increase in amenities has shown an increase in ridership in other research (Hu et al., 2016). Overall, these six categories of human experience and urban planning factors composed an urban quality metric that showed a general positive relationship with ridership.

While categories or types, called typologies, are useful at certain levels of study they have been criticized for occluding deeper understanding of social and economic processes (Ford, 1998; P. Hall, 1966, 1998). Typologies have been criticized for biasing outputs and inherently excluding new or other scenarios (McFarlane and Robinson, 2012; Robinson, 2006, 2011). However, from the previous analysis in this chapter, typologies can be used in collaboration with statistical methods to incorporate place specific detail in analysis. Typologies of transport stations have several components, their station architecture or configuration, the station place context and the stations behaviour or performance.

Recent advances in smart card technology have provided data that shows perceived travel times, speed, limited stops, reliability and comfort are important factors of predicting ridership, however comfort has not been included in many travel demand studies (Van Oort et al., 2015; Wan et al., 2016). A study of bus rapid transit in New York has shown that on time performance and speed are major components of customer satisfaction, as well as other quality factors such as comfort and cleanliness (Wan et al., 2016). From this urban quality survey and mapping exercise it appears the underground speed, central dense locations and transfer opportunities are the strongest proponents of higher passenger rail ridership. Mapping and identifying provides a beginning of understanding the spatial organization of the city. Categories of or types of stations emerge as specific types of operators giving clues to planners of how to achieve aims. Types and categories are discussed in the following chapter.

Urban place quality and mixed uses do not exclude high ridership unless in extreme cases and only slightly. In Los Angeles the underground's speed and central location in dense areas account for a major ridership boon, transfer availability on the system also appears to be a boon. End stations do not promote peaks in either quality or ridership in Los Angeles. These largely overlap with the results from the previous statistical analysis and literature on the drivers of ridership. However, the scale is more human centric and detailed than the numerical offerings of census data. Qualitative tools like the site survey are a way to study components of the user experience, spatial relationships including mapping as diagnosis of how areas may interact, as well as providing for data the census data does not provide.

6.6 Berlin, Hong Kong, London, Medellin Place and Passenger Rail Ridership

Chapters 7 through 10 expand the reach of the previous research to include Berlin, Hong Kong, London and Medellin. These cases can be compared and contrasted with Los Angeles for a variety of reasons. Los Angeles, as a diverse mega city with easy observational comparisons as one moves across the city, high-density financial centres similar to places in London, mixed-use retail and residential areas or artist districts similar to places in Berlin, neighbourhoods influenced by South and Central American populations compare to neighbourhoods in Medellin. It is hard to find comparisons with Hong Kong, as such an extreme example of density, however, green space and hiking trails can be found right next to the urban density somewhat similar to the carved out hiking parks in Los Angeles. Financial strategies are similar between Medellin, London and Hong Kong as well as the materialization of transport policy. However, the reasoning for this collection of five cases revolves around integration of passenger rail with the urban form and reoccurring public transport land use development strategies. The starting point is the Los Angeles case. Berlin's U-Bahn system and London's DLR and Overground are integrated at grade or within one storey of the streetscape much like the four light rail lines in Los Angeles. Medellin's system is fairly new, like Los Angeles, and incorporates transport agency entrepreneurship similarly to the LA Metro's joint development profit making. Hong Kong's MTR system is a dramatic example of passenger rail with less than one-minute boarding during rush hour. Hong Kong's property development is a much more active and successful version of the Los Angeles joint development program.

What can site analysis tell us about these station areas in Berlin, Hong Kong, London and Medellin, including any site analysis, or place, correlations with ridership?

These four other cities were surveyed in the same way as Los Angeles, using the site survey to gauge urban design quality and then compared with ridership trip numbers at each station. The discussion is divided by city, Berlin, Hong Kong, London and Medellin.

A statistical analysis is performed. This expansion is done for a few reasons; the first is to see if any of the conclusions from the Los Angeles chapters are universal. The second is for new knowledge that may come from these investigations. The third is to see how well the model fares or adapts in new contexts of governance and geography.

Over 80 stations were surveyed with the urban quality survey and many more observed through experiential use and mapping. However, only 79 were possible to be matched with ridership data for comparative analysis. From Central Berlin, 18 stations were included for appropriate comparison. Hong Kong, an extreme example of public transport provision was included for a high-end comparison with 15 station areas. London's Overground and DLR somewhat peripheral systems just outside of central London, totalling 20 station surveys, were chosen because of their more apt comparison with Los Angeles' urban centre context. Finally, Medellin's entire system of 27 stations was included because of the similarity in strategy and implementation that it has with Los Angeles. This data reflects the station conditions, and number of stations, for Los Angeles in summer 2013, Berlin, Hong Kong, London and Medellin in spring 2014, This makes for a more comprehensive picture of how transport planning strategy functions and corresponds with the context, despite vast geographic variations and political historical differences.

With the evidence from Los Angeles in mind, the following is a brief synopsis of key issues in the strategic context of each city based on interviews, a subsequent comparison of the urban design quality survey versus ridership, with a concluding section on statistical inferences that can be made from this data.

7 Berlin

7.1 Berlin Background

Berlin is famous in part for its history as a divided city that is still expressed in its transport network with the U-Bahn focused on the western side of the city and the street cars focused on the previously communist side of the city. More recent transport strategies have focused on a unified strategy through the U-Bahn and the S-Bahn (Merrill, 2015). Despite the rich history of Berlin and the prevalence of public transport, including passenger rail, amongst many other innovative mobility strategies, significant scholarly attention has not recently been paid to Berlin (Merrill, 2017).

Figure 38. The Berlin passenger rail system (Berliner Verkehrsbetriebe, 2018).

Berlin, and Germany in general, are sources of innovation in sustainability, transport and transport research. However, a key tension in these agendas is that they have been driven by public policy objectives rather than market demand (Faivre d'Arcier, 2014). Currently, Berlin is experimenting with electric buses and auto sharing to respond to market demands and as low-cost alternatives to heavy passenger rail (Ingvardson et al., 2017). Issues of mobility in Berlin are related to demographic changes similar to other cities (Flemming and Cornelia, 2015). New mobility and mobility concepts in Berlin parallel interventions in Los Angeles, such as their mobility hubs that capitalize on smart phones and auto sharing connecting modes, and further Los Angeles, Medellin and London that have all explored electric buses. Los Angeles and London also have policies supportive of bicycles while cycling in Berlin is high and is an increasing trend (Meng et al., 2014). Furthermore, Berlin and London have been compared for their compact city land use agendas recently (Rode, 2018).

With data mining from smart travel cards, schedule-based transit planning has become a popular tool in transport strategy (Oliveros and Nagel, 2016). Improvements in public transport in Germany have attracted more passengers while at the same time reducing costs, cutting subsidies and increasing productivity (Buehler and Pucher, 2010). These include organizational restructuring and outsourcing of work to subsidiaries and other efficiency and cost cutting strategies including, cutting employee benefits and freezing salaries, increasing work for part-time employees and rises in fares (Buehler and Pucher, 2010). Some of these cost savings benefit the user such as new vehicles with lower maintenance, discounts for monthly users and regional coordination yet other new restrictions are disadvantageous (Buehler and Pucher, 2010). Low use suburban lines have also been reduced to achieve cost savings (Reinhold and Kearney, 2008). However, many cost reductions come from reducing ages or benefits of employees (Buehler and Pucher, 2010). Meanwhile, some evidence supports the implementation of pure infrastructure with these improvements showing reduction in travel times (Ingvardson et al., 2017).

Other research has posited hybrid processes, flexibility and more tailored approaches to address the needs of diverse mobility groups (Rode, 2018). More customers mean more revenues but this thesis investigates the possibility to gain more customers with land use strategies or transport connection strategies rather than punitive market efficiency strategies.

The central city area of Berlin was sampled through place site surveys and the acquisition of passenger rail ridership numbers, stations within a roughly 19.5 square mile area. The images below show the 18 place survey sites in Berlin in a marked satellite map and a diagram over the Berlin transport map with stations surveyed marked within the dashed border. The U-Bahn system had 173 barrier free stations on 10 lines in 2012 and the S-Bahn had 166 barrier free stations and 16 lines in 2017 (S-Bahn Berlin GmbH, 2017; Senate Department for Urban Development and the Environment of the State of Berlin, 2014). The U-Bahn combined with the bus and tram network had 937 million passengers for 2012 (Senate Department for Urban Development and the Environment of the State of Berlin, 2014). The S-Bahn had 436 million passengers in the year 2017 and 1.4 million passenger per work day (S-Bahn Berlin GmbH, 2017).

The U-Bahn entrances straddle on either side or rest within the middle of streets. Platforms are accessed by a brief flight of stairs down below the street. Most stations have multiple portals. The U-Bahn is focused in the western central area of Berlin. There are no ticket gates noticed from this survey and the maps within the station are convoluted and small. At the time of this site survey, the ticket vending machines at stations did not take all kinds of credit or debit cards and purchasing tickets for a foreigner was difficult in spring 2014. The U-Bahn interacts with the S-Bahn at the periphery of the historic centre. Most S-Bahn stations are elevated, with shops within or below, and newer. The S-Bahn is more associated with the regional trains and hauptbahnhof style interchanges between systems. The eastern central part of the city has the tram systems at grade level that were developed during the communist regime and today are a diffuse spread of public transport across the streets. Few stations of any kind are very deep underground, unlike Hong Kong and London. The Berlin multi-modal system is enormous and this place survey focuses on passenger rail of the U-Bahn and S-Bahn through the city centre and parts of the periphery.

Figure 39. The Berlin stations surveyed with pins on map (over Google Maps, 2018).

7.2 Place Site Analysis in Berlin

The place site surveys yielded fairly high results regarding the station areas investigated in Berlin. This is for a variety of reasons, the historical quality and human scale of architectural elements, and likely others. However, the Berlin cases showed that pedestrian quality and urban design amenities rarely corresponded with higher ridership of the U-Bahn and S-Bahn. This suggests that the newer transfer interchanges lack the historic charm of more discreet stations or that wear or congestion may adversely affect the pedestrian realms in Berlin. The following analysis looks at ridership data and the place survey results. The chart below shows the scale or spread of place survey results. There is a large difference between the lowest Kottbusser Tor at 23, and the two stations, Wittenbergplatz and

Oranienburger Tor stations at 43, approximately 46.5% difference. The average place survey result is 33, or 73.3% of the place survey possible, and the median is 32.

Table 15. Berlin stations by place survey ranking.

Station Name	Place Survey Score
Oranienburger Tor U Bahn and Tram	43
Wittenbergplatz Bahnhof	43
WeinmeisterstraBe	40
Friedrichstraße Hauptbahnhof	37
Wedding U Bahn	36
Senefelderplatz	35
Bernauer Straße	34
Rosa-Luxemburg-Platz	33
Franzosische Straße	32
Kurfurstendamm	32
Rosenthaler Platz	32
Alexanderplatz	31
Potsdamer Platz	30
Schwartzkopffstraße	30
Reinickendorfer Straße	29
Zoologischer	28
Wedding S Bahn	26
Kottbusser Tor	23

7.3 Passenger Rail Ridership in Berlin

From this sample of stations, ridership in Berlin appears diffuse with the average of this sample at 65,914 trips in 2007, and a median of 37,643 in 2007 because of some very low ridership stations including Weinmeisterstraße with 8757 trips and Schwartzkopffstraße with 5,743 trips in 2007. Berlin has a similar population to the City of Los Angeles depending on which boundaries are measured but the greater Los Angeles area has many more people. Roughly, Berlin has a larger population than Medellin, and much less than London, Hong Kong and the Greater Los Angeles area. Alexander Platz, Friedrichstraße Hauptbahnhof and Zoologischer are an order of magnitude greater than the other surveyed stations. Interchange opportunities, employment or tourist destinations explain higher ridership in Berlin.

Table 16. The total entries, exits and interchanges at Berlin stations, annual for 2007.

Station Name	Ridership
Alexanderplatz*	75,803,565
Friedrichstraße Hauptbahnhof*	68,772,205
Zoologischer*	63,851,640
Potsdamer Platz*	26,859,620
Wittenbergplatz Bahnhof*	22,953,755
Kottbusser Tor*	17,818,205
Kurfurstendamm*	17,740,460
Wedding S Bahn*	13,739,695
Wedding U Bahn*	13,739,695
Rosenthaler Platz	7,187,215
Oranienburger Tor	6,175,070
Franzosische Straße	5,394,700
Rosa-Luxemburg-Platz	4,915,455
Bernauer Straße	4,508,845
Senefelderplatz	3,981,055
Reinickendorfer Straße	3,914,260
WeinmeisterstraBe	3,196,305
Schwartzkopffstraße	2,096,195
* Rail Transfers Available	

7.4 Case Studies in Berlin

The most noteworthy stations included in the following place case studies are the three highest place quality stations, Oranienburger Tor, Wittenbergplatz and Weinmeister Straße. The case studies presented for a discussion of high passenger rail ridership are the five highest performers, Alexanderplatz, Friedrichstraße station, Zoologischer Garten, Potsdamer Platz and Wittenbergplatz. Wittenbergplatz is a combined discussion.

7.4.1 Oranienburger Tor Station

Oranienburger Tor was determined to have the highest quality environment for pedestrians surrounding the station with a 43 out of 45 on the urban place survey. The station is located in Mitte or the middle of the city in a formerly up and coming neighbourhood that is now firmly bourgeois bohemian.

Figure 40. Oranienburger Tor station area.

The area has many restaurants, shops and housing. Plentiful shop awnings and architectural entryways provide shade and protection from the rain. Street trees also provide some protection and a pleasant environment for pedestrians. This underground station sits in the middle of the wide street with a stairway entrance at each end of the underground platform. On each end there is a tram station at the street level to one side depending on the direction of travel. The steps down to the underground station are approximately one flight only. Public transport is present throughout the street as well as pedestrians. The street contains tram lanes and a centre divider for the underground station access, therefore cars to do not dominate and are not able to drive quickly. Pedestrian barriers at intersections have been consumed by bicycle parking identifying the bicycle friendly nature of the area. Many of the pedestrian amenities come from the rich mixed-use nature of the neighbourhood, the historic craft and human scale of the buildings. The nearby S-Bahn station was similar but less in place quality. At the S-Bahn station, the street for autos is larger and while cafes are present they are not as abundant as near the U-Bahn station. While less pedestrian friendly the S-Bahn area is still mixed-use and has a nearby park.

7.4.2 Wittenbergplatz Station

In the Berlin study, Wittenbergplatz is the only station that has made the top five in stations surveyed for ridership and urban design quality. Wittenbergplatz sits in the middle of a mid to high-end shopping and tourist district. The underground station sits in a large grassy park in the centre of the street. U-Bahn connections and ample bus service adds to the intensity of the area. The atmosphere is active yet leisurely as large sidewalks sit next to two lanes of traffic, then a wide central parkway with benches, two more lanes of autos and another wide sidewalk on the other side with detailed buildings on either side. The proportions and central pedestrian path take the danger and fear out of what could be a fast moving multi lane street. The historic remains of Kaiser Wilhelm church can be seen in the distance adding a nice layering affect between the older buildings with more contemporary ones. Wittenbergplatz presents a powerful case, similar to Los Angeles' Hollywood stations, that tourist or shopping destinations can be an organizing principle for public transport.

Figure 41. Wittenbergplatz station area.

Figure 42. Wittenbergplatz station area.

Wittenbergplatz is the fifth most successful station in terms of ridership in the study of Berlin's system. The station is located in central Berlin in a beautiful renovated building on a plaza that is set within from a major shopping boulevard. The station only serves the U-Bahn but, provides access to three lines. Tall buildings of a variety of uses surround the station. 62,887 trips were recorded from entries, exits or transfers at Wittenbergplatz. The dominant use of this station seems to be the large amounts of commercial and retail uses, as well as some offices, provided for tourists and locals.

7.4.3 Weinmeister Straße Station

Weinmeister Straße is nearby and gentrified with graffiti art and international clothing store chains. The area surrounding the station is pleasant for pedestrians because of the scale of buildings and streets as well as the commercial attractions around. It is a central location with high end shopping and eating. The side streets are a bit more pleasant with street trees and small shops.

Trams run through this section but there are no immediate stops and the portal to the underground is accessed on either side of the street on the sometimes too slim sidewalks. This station is very near to the other stations but was noted to be less in place quality and pedestrian atmosphere because of the homogenous international quality of some of the buildings and shops and overall less detail in the built environment and architecture.

Figure 43. Weinmeister Straße station area (after Nicholaou, n.d. from Google Earth, 2017).

7.4.4 Alexanderplatz Station

Of the Berlin stations I have ridership data for, Alexanderplatz had the highest ridership numbers with 207,681 trips per day in the year 2007. These high numbers are likely owed to a variety of factors, available transfers, tourism, employment and density. Alexanderplatz was a major bastion of communist architectural expression before reunification and today is a major public transport hub and site of contemporary development. Of course, the history of Alexanderplatz is much longer but the communist style and scale, is still visible. The scale of street blocks and buildings are expansive in the communist style and this legacy remains an impediment to pedestrians and street quality to this day. However, Alexanderplatz is lively with foot traffic and a heavily used transfer hub, as evidenced by the ridership numbers. Alexanderplatz has been the site of major redevelopment during the communist control, and more recently with the Hauptbahnhof. Alexanderplatz is now one of the major transfer hubs in Berlin with U-Bahn, S-Bahn, tram, regional train and bus connections.

Figure 44. Alexanderplatz station area.

7.4.5 Friedrichstraße Station

Friedrichstraße station was a close second in passenger rail ridership to Alexanderplatz with 188,417 trips in 2007. Previously divided by the Berlin wall, the Friedrichstraße area is now a cultural and shopping centre in the middle of the city next to the large Tiergarten park and adjacent to the national government buildings. The larger area of Freidrichstraße is home to many transport connections. The station is in the hauptbahnhof style, a transport hub with retail and sits at the end of a major shopping street near to Unter den Linden, an important government, university, tourist and shopping destination. The area surrounding the station is extremely mixed-use, with shopping, hotels, government offices and historic sites such as Brandenburg Gate, the Reichstag and Checkpoint Charlie. This dense fabric of overlapping uses in a central location partly explains the extremely high ridership numbers of Friedrichstraße station. Furthermore, Friedrichstraße is a transfer point for regional trains, the S-Bahn and the U-Bahn within the station and the trams outside on the streets throughout the area.

Figure 45. Friedrichstraße station area.

7.4.6 Zoologischer Garten station

Zoologischer Garten station is named after the zoo that it serves. This station has all the amenities of Friedrichstraße but is a bit further removed from the intense shopping. The Zoo provides a tourist draw for riders but there are also offices, hotels and restaurants servicing the area. Zoologischer Garten has the added intensity of being a transfer point for the S-Bahn, the U-Bahn and provides connection to the regional train service. This was a major western transport hub before the building of the Berlin Hauptbahnhof.

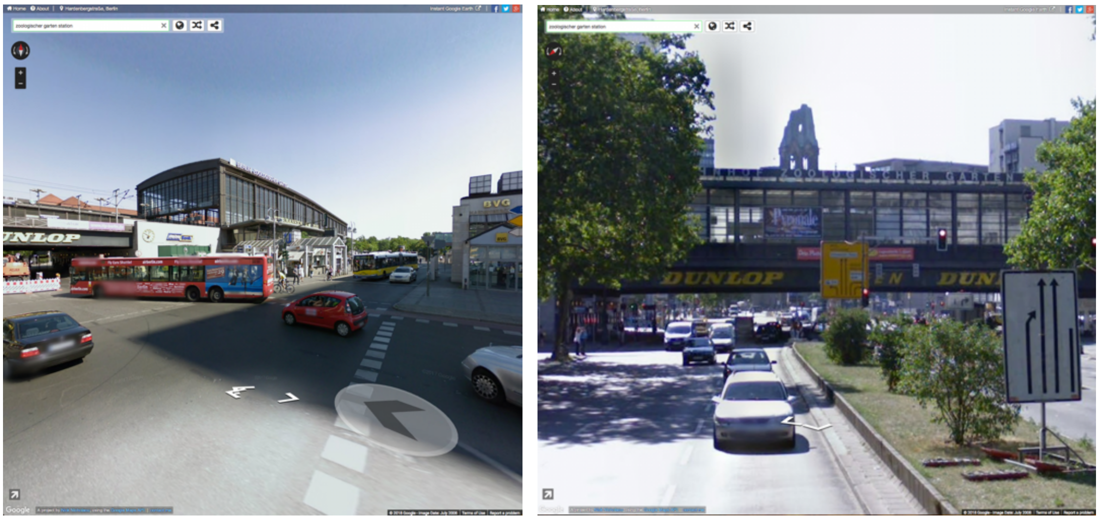

Figure 46. Zoologischer Garten station area (after Nicholaou, n.d. from Google Earth, 2017).

7.4.7 Potsdamer Platz

In between Zoologischer Garten station and the Friedrichstraße station, at the corner of Tiergarten park is Potsdamer Platz, another transfer hub and an area that has been intensely invested in including large scale contemporary architecture. Office buildings, residences and hotels have filled in this area yet it still is spacious and at an expansive scale. Buildings are striking, shopping and restaurant space were provided, yet the area lacks a human scale and seems stark. Still, the ridership levels of Potsdamer Platz station are very high at 73,588 trips in 2007 but are significantly lower than the next station higher, Zoologischer Garten that pulls in 174,936 trips. Potsdamer Platz is central and a tourist zone but, it lacks the charm and possibly the integrated mixed-used streetscape of other parts of Berlin. Buildings seem to be for mostly segregated uses. The architecture and spaces of this area are in the modernist utilitarian vein with large blocks of programmed space, and a surprising lack of street level commercial at the bottom of these towers and an overall lack of human scale detail.


Figure 47. Potsdamer Platz station area (after Nicholaou, n.d. from Google Earth, 2017).

7.5 Comparing Place with Passenger Rail Ridership in Berlin

Comparing the place survey results with passenger rail ridership through mapping shows that the major interchange hubs across the middle belt of the city attain much more passenger rail ridership. However, while a diverse sample, this sample is fairly small and much more investigation into geography, station location and the affect that interchanges have on passenger rail ridership is needed. On the east side of the former Berlin Wall is a tram network and in formerly West Berlin there is a more complex underground network. The difference between East and West Berlin can still be seen in architectural style today. However, from the place analysis and ridership analysis there appears to be little distinction. Broadly, passenger rail ridership is a bit higher across the south side of the city yet more research into this to look at population centres or density is necessary to determine possible reasons for this slight higher amount of ridership. The most apparent conclusion from the mapping studies is that the major transfer hubs have much more ridership than the other stations. With Berlin's rich tram, bus and passenger rail network, virtually any station is a transfer station yet the stations with regional train connections have added to ridership.

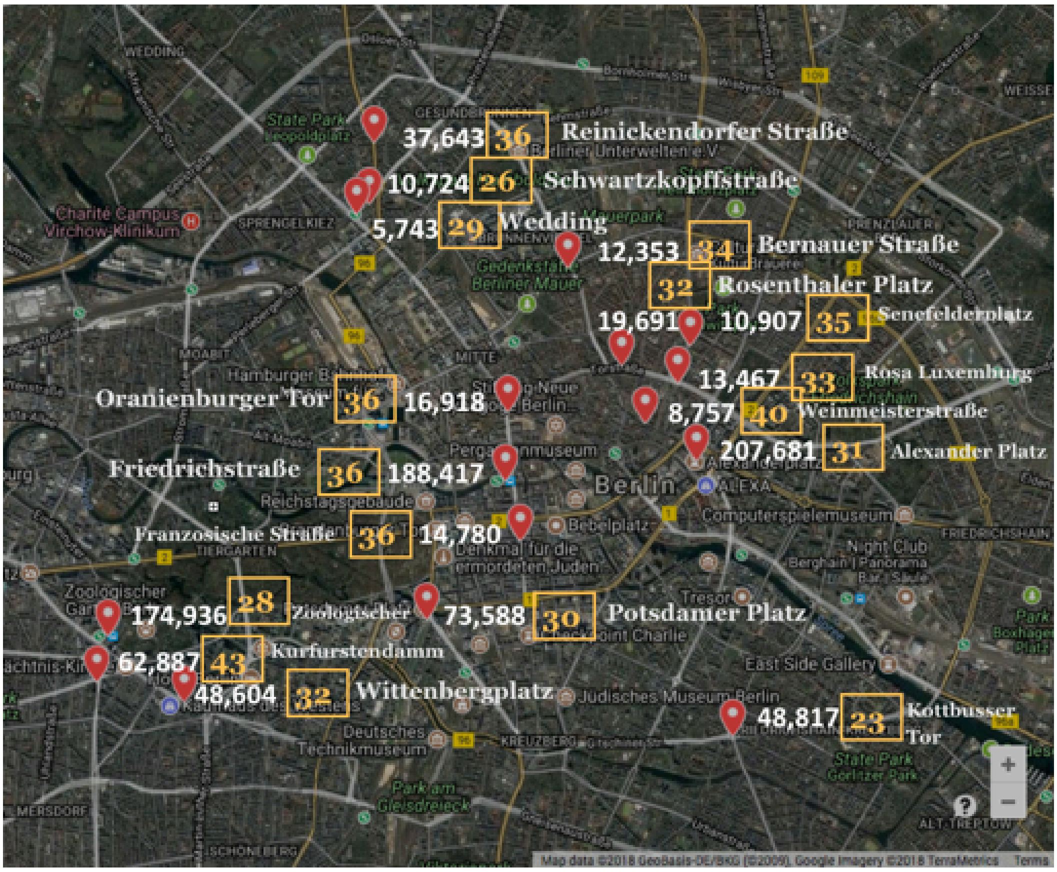

Figure 48. Passenger rail transport ridership numbers of stations and the place quality survey numbers are outlined near their corresponding stations (over Google Maps, 2018).

The place survey is likewise fairly distributed. This could be because pre and post Berlin Wall architecture exists on both sides due to reconstruction after World War II. S-Bahn stations tend to be less mixed-use conditions, of a larger scale and above ground condition, of an acupuncture style rather than the subtle underground stations that are one flight of stairs down underneath mixed-use neighbourhoods. Berlin's place quality by ridership chart resembles Los Angeles' with three stations performing radically different in terms of ridership, Zoologischer, Friedrichstraße and Alexanderplatz. These are all of the super hub configuration, transfer junctions and with retail. However, Potsdamer Platz is of a similar configuration if in a different context and has lower ridership numbers. The Alexanderplatz hub runs highest on the ridership spectrum, 207,881, from these stations and has a near average place survey result, 31. The Friedrichstraße is the station with the second highest ridership, 188,417, presented here and the fourth highest quality of station area.

Friedrichstraße is in a central location with a new Hauptbahnhof style station off of a busy commercial street. These cases show that place quality and substantial ridership can be integrated and major trade-offs are not necessary.

Figure 49. Map of the place quality survey by passenger rail ridership in millions.

8 Hong Kong

8.1 Hong Kong Background

In Hong Kong there has been an increased attention to sustainable development (Nichols, 2015). Hong Kong's underground heavy rail system is impressive and well used (Nichols, 2015). Yet, even in Hong Kong urbanisation continues rapidly even with environmental protections and there is room for improvement because rail fares are high and pollution from automobile use still needs to be reduced (Nichols, 2015).

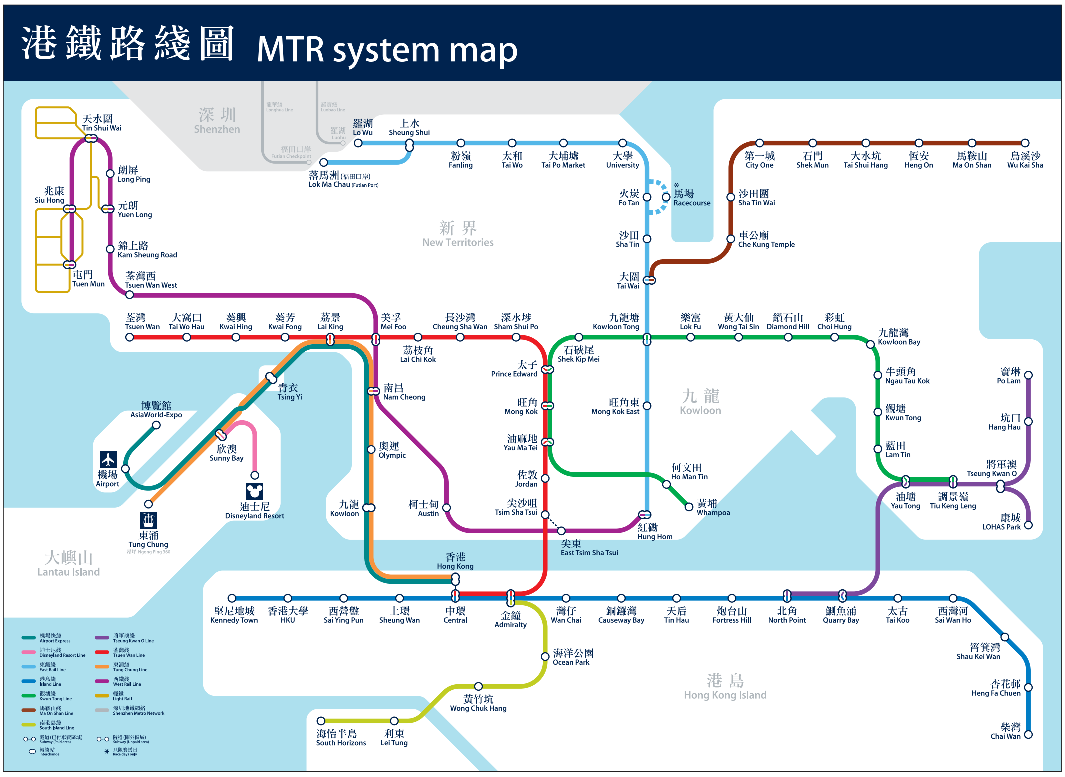

Figure 50. The Hong Kong passenger rail system (MTR, 2018).

In Hong Kong, shopping and recreational factors had a significant relationship with trips shown in commercial centres, reflecting the land use development strategies of the MTR agency's motives (Wang et al., 2015). Property development, transit-oriented development, and transports impact on land development are popular with politicians, planners, academicians, investors and developers largely because of the MTR's visible property development visible successes (Guan, 2015). Transport development is seen as an economic growth engine with the built environment shaped by transport in Hong Kong (Guan, 2015). Higher speculative land prices exist near stations (Guan, 2015). Planning applications also focus around stations (Guan, 2015). Transport is seen as attractive to stakeholders due to higher property values and the MTR has used property development to further that perception and effect through channelled development (Guan, 2015). Carbon emission reductions have also been a prominent policy of the European Union and the United Kingdom (Banister et al., 2008; Hickman and Banister, 2007; Hickman et al., 2009).

Hong Kong’s passenger rail ridership numbers overall are extremely high and due to the strategy of focused development. Public transport is focused on the passenger rail system unlike Berlin where users have a variety of transport options. In Hong Kong, the routes and the population are very centralized. The Hong Kong MTR’s focused property plus rail strategy has focused commerce and population above and around the underground passenger rail lines. This is feasible in Hong Kong due to the government ownership of land and the close relationship between the predominantly government owned MTR. The government is the largest shareholder of the MTR. Hong Kong focuses urban form along public transport routes. Hong Kong’s ridership doesn’t vary much from weekday to weekend for most central stations.

The Hong Kong system is predominantly made of deep underground passenger rail lines with high-rise development above. The Octopus card is very useful as a tap card through platform gates and is accepted at many stores in Hong Kong as well. Most stations underground have retail within them just outside of the platform areas, that the larger numbers of commuters use daily. Virtually all stations are deep with massive amounts of development above and multiple exits, at multiple levels, that snake underneath and through the city. University station the exception located in a campus setting. The MTR interacts with a previously separate system that runs more at grade on the mainland side but these are now consolidated. From Central Station trains connect to the airport, China, Disneyland and there is a visible historic tramline that runs along the island side through commercial areas. Flight check in and luggage drop off occurs in the city at the International Finance Centre mall with an approximately twenty-minute train ride to the airport. Taxis and private minibuses are prevalent on city streets. There is also a light rail system out in the western side of the mainland. This place and passenger rail study looks at the underground system of the MTR, their station areas, concentrated in the central part of Hong Kong.

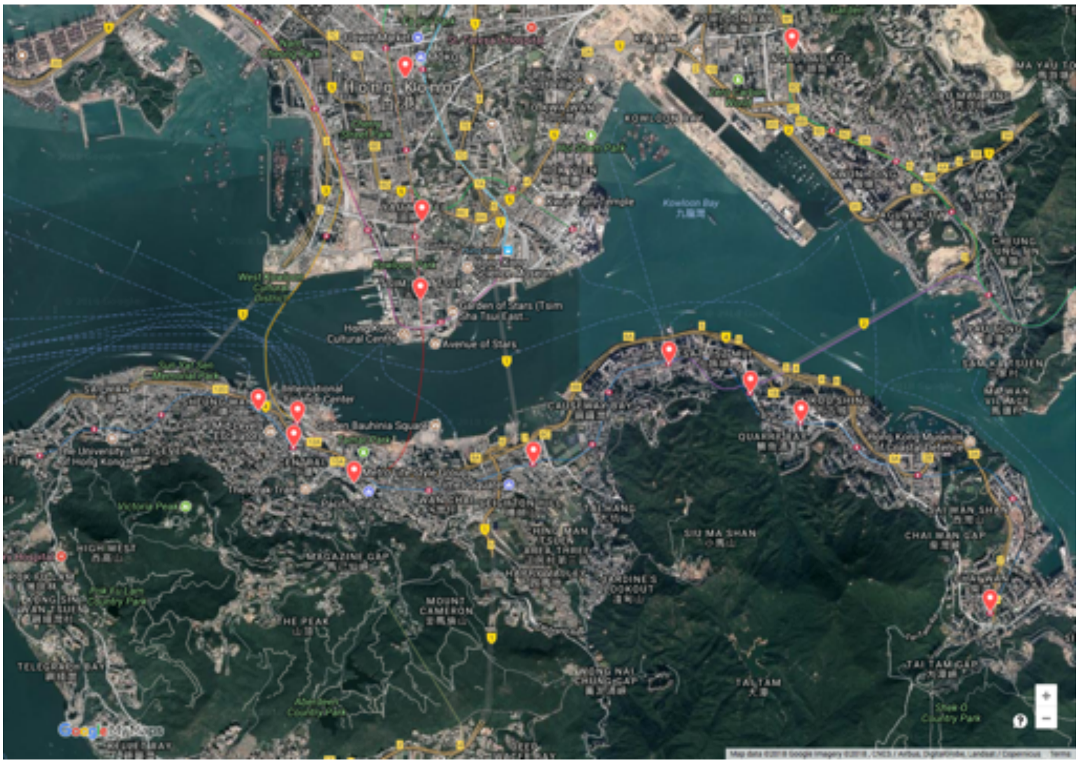

Figure 51. The Hong Kong stations surveyed with pins on map (over Google Maps, 2018).

8.2 Place Site Analysis in Hong Kong

The place survey results are slightly lower than Berlin's despite the intense property transit-oriented development strategy in Hong Kong. The Hong Kong case has an average place study result of 29 and a median of 30. Some older station areas suffer from density with congestion, tight quarters and overuse. The newer stations within a more spacious built environment result in higher scores on the place survey yet, suffer from a lack of connection to the street and monumental scales.

Kowloon Bay the first transit-oriented development and the headquarters of the MTR had the highest return on the place survey with Chai Wan and University stations on the periphery of the system also were on the higher end of the place survey. Chai Wan and Kowloon Bay have transit-oriented and commercial investment at the station but are of slightly less intensity than the central areas. University station is an outlier with a site within a college campus rather than a high-density commercial and residential district.

Table 17. Hong Kong stations by place survey ranking.

Station Name	Place Survey Score
Kowloon Bay	38
University	34
Chai Wan	34
Admiralty	33
Tseung Kwan O	32
Tai Koo	32
Hong Kong Station	31
Causeway Bay	30
Mong Kok	27
Tsim Sha Sui	27
Jordan	26
Quarry Bay	25
Central	23
North Point	22
Sheung Wan	20

8.3 Passenger Rail Ridership in Hong Kong

Passenger Rail ridership is focused roughly around the central commercial and employment areas of Hong Kong. Mong Kok, one of the only interchanges and a central station in an intense mixed-use dense area has the highest ridership at 307, 834 trips per weekday, followed by the other central stations Admiralty, Central and

Causeway Bay. These are all visibly employment and commercial areas with surrounding residential uses. These four stations are well above the average passenger rail number of 171, 595 and the median at 150,850. University station has the lowest passenger rail ridership of this cohort at 79,492 per day. University station is in a periphery area and has a lower density campus condition that predominantly serves the University and surrounding residences. A preliminary hypothesis from this mapping would include noticing the commercial nature of the highest passenger rail ridership stations including Causeway Bay, Central station and Mong Kok. It is also worth noting that Mong Kok and Tsim Sha Sui have a built environment above them that is a blended condition with some buildings that were developed over time, and some that are new and transit-oriented.

Table 18. Estimated annual trips in Hong Kong, entry and exits.

Station Name	Ridership
Mong Kok*	112,359,410
Causeway Bay	108,011,165
Tsim Sha Sui*	104,478,330
Central*	98,056,885
Kowloon Bay	72,607,625
Admiralty*	59,055,175
Jordan	58,242,320
Sheung Wan	55,060,250
Tai Koo	46,313,025
Tseun Kwan o	44,517,225
Hong Kong Station*	42,556,080
Quarry Bay*	38,571,375
Chai Wan	37,196,055
North Point*	33,442,760
University	29,014,945
* Rail transfer stations	

8.4 Case Studies in Hong Kong

Place case studies are presented in the following paragraphs, including the MTR headquarters and first transit-oriented shopping mall development Kowloon Bay, as well as Admiralty, Tai Koo, University and Tseung Kwan O stations. The stations included for their noteworthy passenger rail ridership numbers were more outside the MTR transit development strategy and more within the complex central areas of Hong Kong, including Mong Kok, Causeway Bay, Tsim Sha Tsiu and Central station. The planned MTR headquarters and first transit-oriented development, Kowloon Bay, was included in both place and passenger rail case studies.

In general, the Hong Kong stations fared less well in terms of place quality and pedestrian friendly atmosphere than Berlin, in part because of the compact urban environment and also the masses of people surrounding the stations. However, many stations show the major financial investment instilled and a new way of treating pedestrians through sky bridges, that are actually very well used despite Jane Jacobs' historic bias, and by focusing on planning the pedestrian experience beyond the surface street (Jacobs, 1961).

8.4.1 Kowloon Bay Station

Kowloon Bay is a station included for its place score and for its high ridership. The ridership success is likely due to planned development rather than a central commercial location. The Kowloon Bay station is similar to a Los Angeles transit-oriented development with its busy but not overwhelming associated shopping mall and office space. The shopping mall has a pleasant and large outdoor plaza that relives a lot of the overstimulation common in Hong Kong spaces. It is difficult to say what the connection with the street is because the shopping mall, plaza and train station are inward facing, elevated and removed from the street level. Kowloon Bay has more of a human scale than the other Hong Kong station areas and is not as chaotic as some others. This is the site of the MTR headquarters and a clear expression of their development plus rail strategy. There are large residential towers along the route of the MTR line as well as commercial and green space. The residences and MTR shopping mall around Kowloon Bay station are the planned result of focused development and a prototype of the MTR Malls program. The general strategy in Hong Kong is to purposely segregate pedestrians away from the street and autos, through pedestrian overpasses and building corridors. However, some activities such as mini bus connections do need to occur at the street level. The MTR's hub sits outside of central Hong Kong and connects with the other rail lines in a roundabout way but it still has substantial ridership numbers. This focused development and large population, despite a non-central location, provides 198,925 trips on a weekday and 147,956 trips on the weekend.

Figure 52. Courtyard at podium level of Kowloon Bay station, connected to a large shopping mall and MTR headquarters.

8.4.2 University Station

University station is set into the landscape at grade level. There isn't enough space in many places in Hong Kong for modes to interact, negating the private car in many places but pedestrians, taxis and shuttle buses and the occasional work truck or shipping truck all squeezed together.

Figure 53. University station, an outlier in terms of green space.

The University station is located at the Chinese University of Hong Kong in what is called the New Territories on the mainland side of the Special Administration Region. The station is a low building located at the edge of the campus with only a few small shops for snacks. The offerings seem especially small for this large area. After being deposited in this location it is difficult to know where to go as the station sits in a small valley by a stadium and not an active centre of the University. Furthermore, the picturesque surroundings of the harbour are blocked on one side by a roadway. The unassuming station could use some better signage and orientation but the green surroundings and seating are a pleasant respite from the hectic travel of other areas of Hong Kong. University is one of the only stations in Hong Kong with a significant difference between weekday and weekend numbers of station patrons.

8.4.3 Admiralty Station

Admiralty is an extremely wealthy shopping, tourist and office district with a complex network of entrances to the deep underground line. The station is characterized by a high-end shopping mall with several hotels above it. Nearby are the government offices and a new park on the harbour between Hong Kong Island

and Kowloon. The shopping mall and surrounding area are a bit more spacious and calmer than the crowded streets of the adjacent central area. The area is undoubtedly for a wealthy clientele and lunch or breakfast snacks during a commute are hard to find with restaurants in the mall predominantly formal. Also, the grocery store and restaurants open well after rush hour in the mornings. This shopping mall is more of a luxury mall rather than useful for everyday life. There is a steep grade on the south side and many herding barriers prevent pedestrians from walking out into the street. Office buildings have access to the mall and station via sky bridges or underground tunnels. The pedestrian experience is reconceptualised and planned for pedestrian transport routes though buildings. There are open spaces and parks nearby and there is some sitting space in front of the shopping mall. Travellers on the underground line don’t have to travel through the mall and can access different exits via underground tunnels to streets or buildings nearby if they are experienced with the systems.

Figure 54. Admiralty, a combination of public area, streetcars and buses with an interior shopping mall transit-oriented development and underground system.

8.4.4 Tai Koo Station

Tai Koo station is another integrated shopping mall station on the island east of central Hong Kong. This shopping mall caters more to residential and office working locals with restaurants and services, including attractions for families. The underground station has pedestrian routes that branch out into and beyond the mall in many directions. The area outside of the station has some problems but in general is very good for Hong Kong in terms of sidewalks and pedestrian integration at the street level. The area is mixed-use with the shopping mall, other retail and housing towers. Some drawbacks represent the disadvantage of urban design quality at most Hong Kong stations such as pedestrian barriers to pen people, poor signage and no outdoor seating. Tram and bus connections are obvious and easily accessed from the station though. Overall there is a nice mix of shopping and uses around the station but sidewalks can be cramped. Pedestrian interior access routes through malls take some time to understand how to navigate.

Figure 55. Tai Koo, a mixed-use area with residential, shopping and office.

8.4.5 Tseung Kwan O Station

Tseung Kwan O is another of MTR's shopping mall train stations. However, Tseung Kwan O is not entirely introverted. There is a streetscape surrounding two large shopping mall buildings and some elevated plazas or parks within the shopping development. Bus connections are easy and visible. Housing towers surround the mall and there are several additional MTR entrances not too far away. The area is generally planned to be inward facing with a large interior plaza in the middle of the mall but the nearby bay is barely visible much less accessible for leisure. Few street elements such as benches or overhangs are present. Still, the area is mixed-use and fairly straight forward if a bit desolate outside of the mall.

Figure 56. Tseung Kwan O, the underground access, like most in Hong Kong, is entered through the shopping malls shown on either side of the road (after Nicholaou, n.d. from Google Earth, 2017).

8.4.6 Mong Kok Station

Mong Kok, the most used station in Hong Kong is centrally located on the Kowloon mainland side. On a weekday it has 307,834 trips and, on a weekend, only a fraction less at 302, 333 trips for the year 2013. The station sits in the middle of the enormous Kowloon shopping and commercial centre that is an international tourist destination. Two passenger rail lines can be accessed from the station. Much of Hong Kong is dense and mixed-use but there must be some characteristics that make Mong Kok more highly used than the other stations. The station is central to Hong Kong as a whole, in between China and the employment nodes on Hong Kong Island called Central. The most striking aspect of the area and a possible reason or the high ridership is the enormous layer upon layer of shopping, office and commercial uses. Also, Mong Kok is a transfer station. A two-line intersection would not mean much in Berlin where many lines overlap but, in Hong Kong transfer stations are not as prevalent. There are many less lines in Hong Kong and lines do not overlap but service for lines repeats very rapidly. Shuttle buses make connections up the hills from the underground lines.

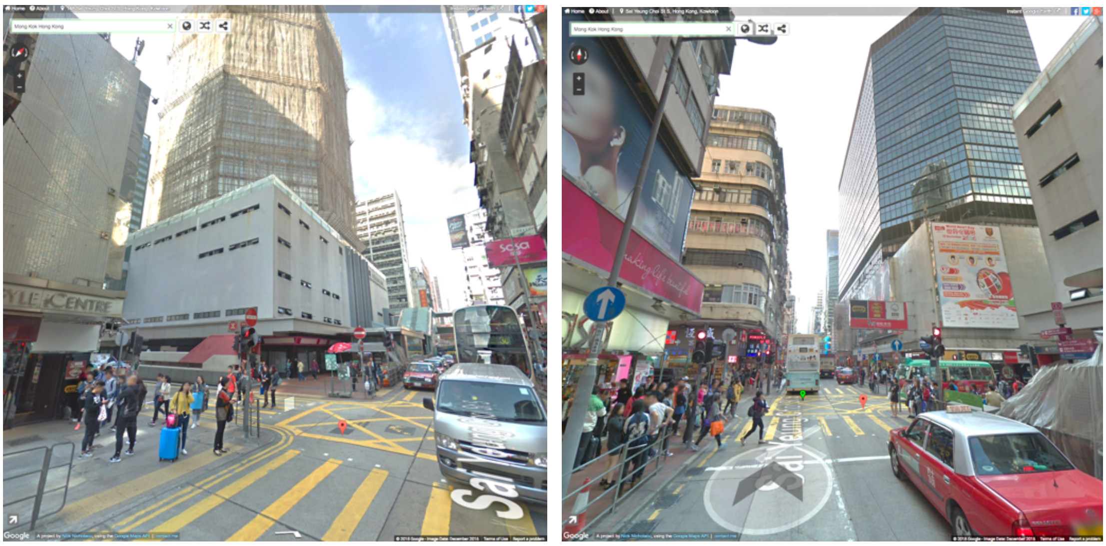

Figure 57. Mong Kok station area (after Nicholaou, n.d. from Google Earth, 2017).

8.4.7 Causeway Bay

Causeway Bay is also an enormous shopping district but better maintained than Mong Kok. This major shopping area returns 295,921 weekday trips and 275,357 weekend trips. Causeway Bay station is on the Island Line that runs on Hong Kong Island. There are also large parks for leisure and sporting events in the area as well as a busy harbour. The district Causeway Bay is adjacent to populous residential areas and office districts. There is a lot of nightlife in this district. At first glance Causeway Bay's ridership seems to be driven by the shopping but, after more visits it becomes clear that there is a great visible density of housing, restaurants, commerce and office uses. Causeway Bay station is not a transfer station but the building heights tend to be higher and residences more in demand on the Hong Kong Island, as opposed to the Kowloon mainland.

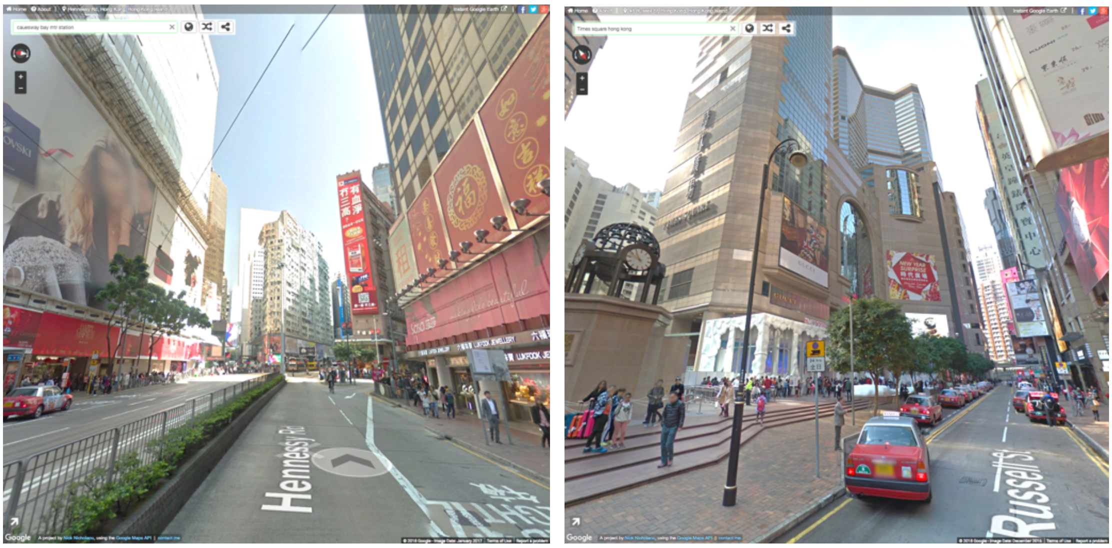

Figure 58. Causeway Bay station area (after Nicholaou, n.d. from Google Earth, 2017).

8.4.8 Tsim Sha Tsui

Tsim Sha Tsui has a very similar condition as Mong Kok. It is centrally located at the edge of Kowloon, on the mainland, with a waterfront that looks over the skyline of Hong Kong Island. Tsim Sha Tsui is also a transfer station but only by a technicality in the form of an underground walkway from Tsim Sha Tsui station to East Tsim Sha Tsui station. The area surrounding Tsim Sha Tsui is more spacious than Mong Kok with nearby high-end hotels and tourist attractions including a large park near the entrance. The station is walking distance to the waterfront, large museums and cultural centres. Extremely tall towers of various uses and extensive shopping opportunities fill Tsim Sha Tsui, drawing 286,242 trips per day in 2013, slightly less passenger rail traffic than Mong Kok.

Figure 59. Tsim Sha Tsui station area (after Nicholaou, n.d. from Google Earth, 2017).

8.4.9 Central Station

There is very little discrepancy between weekday and weekend travel for these central stations except for Central Station. Central Station is predominantly an office district with shopping and proportionally little residential. Central station is the shiny jewel of the MTR with extreme high rises and high-end shopping. This station was developed through a land reclamation scheme that took land from Hong Kong harbour. This modern shopping complex includes check in desks for flights and an express train to the airport. Ridership during the week is at 268, 649 trips per day in 2013 and a dramatically lower number of trips during the weekend at 147,956. Of the top stations in Hong Kong this is the largest drop in percentage and number between weekday and weekend travel. Lack of weekend employment, residents and leisure activities must be the source of this drop in this largely financial and office district.

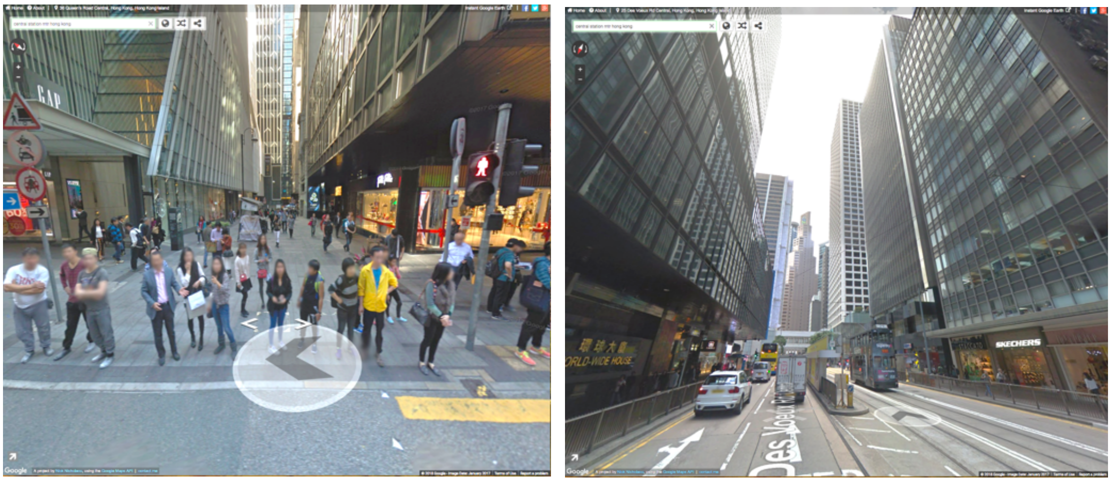

Figure 60. Central station area (after Nicholaou, n.d. from Google Earth, 2017).

8.5 Comparing Place with Passenger Rail Ridership In Hong Kong

Comparing peaks in passenger rail ridership with peaks in the place reveals a few interesting stations notes. North Point station is second to lowest in the place metric and the lowest in passenger rail ridership from this group. Overall, the mean of the passenger rail ridership is lower than the averages showing that there is a larger group of the lower number of passenger rail ridership values, despite larger numbers of the successful stations pulling the average up. The opposite is true of the place mean with more values being on the higher side than the average, with some low place scores pulling down the average. The average weekday passenger rail ridership of these stations is 171,595 with an average of 28.9 on the place survey. The mean passenger rail ridership value is 150,849.8 and the mean place value is 30. The place value of stations varies less than passenger rail ridership. Passenger rail ridership was more concentrated around the centre of Hong Kong in shopping and retail areas Mong Kok, Causeway Bay, Central, Tsim Sha Sui. The place scores for each of these were in the lower half of station areas surveyed. Causeway Bay, a major leisure and shopping area, has the highest place survey score and is the second highest ridership station. A few general hypotheses stand out other than the possible wear and congestion the more travelled stations might have negatively on the place aspects, and that Kowloon Bay the transit-oriented development, has the fifth highest passenger rail ridership numbers and the highest place survey score, despite its peripheral location, making the case that planning and transit-oriented development can counteract a non-central location.

Figure 61. Passenger rail transport ridership numbers of stations and the place quality survey numbers are outlined near their corresponding stations (over Google Maps, 2018).

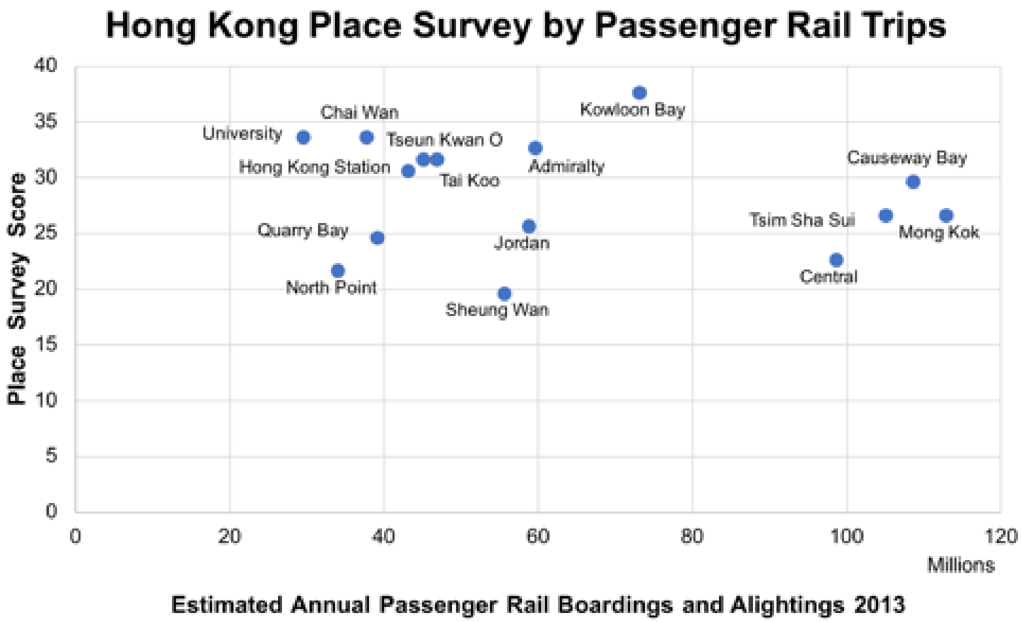

Figure 62. Map of the place quality survey by passenger rail ridership in millions.

9 London

9.1 London Background

The analysis of London is focused on two lines, the Docklands Light Railway (DLR) and the London Overground. The London Overground is a system of new and pre-existing tracks that have been combined to make an orbital route of inner London, reaching several places previously untouched by rail. The Overground was launched in part, in 2007 (Transport for London, n.d.). The DLR opened in 1987 connects two financial centres, the City of London and Canary Wharf (Transport for London, n.d.b). The DLR is a light railway and has an elevated condition for much of its path whereas the London Overground moves along traditional tracks and has varied station conditions. These two lines were of interest for analysis because of their connection of peripheral or suburban centres, that made for a good comparison with the Los Angeles case. The DLR and the London Overground are also somewhat novel, connecting subcentres and in the case of the Overground repurposing, redesigning and connecting previous rail lines for a more affordable approach to a contemporary system.

The London system is very diverse with an underground line, a predominantly elevated over ground line, a light rail way and a tram system in Croydon. The system is made of new and old, or refurbished, railways. London even has a short cable car line that crosses the river. The London system operated by Transport For London has an Oyster card that is similar to the tap cards used for tickets in Los Angeles and Hong Kong, though not as widely useful as Hong Kong's Octopus card. Fares for the London system are commonly thought to be very high. The place and urban design survey of the London system includes the London Overground, some London Underground stations and the Docklands Light Railway (DLR). The London Underground system is very deep often requiring a trek from ticket gates to platforms. The DLR and the Overground usually have platforms near grade, one level above or below, and often uncovered. The Overground was combined partly from previously existing train tracks. Crush levels at certain central stations, like Bank or Euston, are reminiscent of rush hour in Hong Kong.

London opened the first underground passenger rail line in 1863 from Paddington to Farringdon (Dobbin, 2012). This steam operated line was an instant success followed by many subsequent rail lines including the District and Circle railways (Dobbin, 2012). In 1890, the first deep level underground line opened in London and today constitutes part of the Northern line (Dobbin, 2012). The Victoria line was the first computer controlled underground line and was launched from 1968 to 1969 with automatic trains and ticket gates (Dobbin, 2012). In 1977 the Piccadilly line reached Heathrow airport (Dobbin, 2012).

The Docklands Light Railway was opened in 1987 and has since doubled in length (Dobbins, 2012). In the year 2000, Transport for London was created with a much larger remit than the previous transport agency, London Transport, and is answerable to the mayor’s office, with control of the bus, underground taxis, river services, cycling, main roads and traffic control (Dobbins, 2012). Similar to Transport for London, the LA Metro is responsible for several modes across the county and interplays with other transport agencies that have complementary services (Dobbins, 2012). At over 150 years old the London passenger rail system is a fundamental part of London life (Dobbins, 2012).

Besides firsts, the London underground system continues to grow and incorporate new transport inventions. The effects that transport and development have on each other can be seen in the London laboratory (Hickman et al., 2017). London is the exemplar of the trend of people and resource shifts from smaller urban centres to larger urban centres, London being the largest city in the United Kingdom with the most economic pull (Hall et al., 2001). Cities like London are the place people are moving to from sinking, formally industrial, cities (Wiechmann, 2008). London is a unique spread of low densities, a centre of growth, and one of the world’s great attractors of immigrants along with New York and Los Angeles (Hall, 2007).

Passenger rail and transport in general, must keep up with this influx of people and workers.

A recent criticism of passenger rail is that it facilitates gentrification and the outmigration of pre-existing residents or businesses. Gentrification is a product of cosmopolitan lifestyles (Harris, 2008). Yet, gentrification is too generalized a term and there are many types of gentrification including that caused by low-income students and artists (Harris, 2008). London's property market is gentrifying for a variety of reasons. However, this movement of capital and reorganization partly around new transport lines is evident in London and important to be conscious of in planning and transport to balance spaces of consumption with spaces of production (Smith, 1979).

London continues to be composed of areas of increasing density and also have high rates of poverty (Dorling and Thomas, 2016). Four of the most densely populated areas were in London by 2011, with all of the greatest increases in density in London, excepting Manchester and Leicester (Dorling and Thomas, 2016). Meanwhile, 14 London boroughs had higher poverty rates than Glasgow and Belfast in 2011 (Dorling and Thomas, 2016). Despite the amount of passenger rail and other public transport modes, data from 2011 shows that most people still commute to work by car (Dorling and Thomas, 2016). Nearly 60% of working people commute by car (Dorling and Thomas, 2016). At the same time, London shows a promising trend with the greatest increase in the proportion of households without a car available (Dorling and Thomas, 2016). London is where population is rising and space is falling but also where the modes of travel are shifting towards more sustainable modes with rail commuters growing by 27% from 2001 to 2011 (Dorling and Thomas, 2016). Use of the London underground system has grown by 43% from 2001 to 2011 (Dorling and Thomas, 2016). Since 2011 the use of the London underground has steadily risen along with distances travelled (Dorling and Thomas, 2016).

The underground and DLR systems had a combined 2.8 million trips approximately (Transport for London, 2018c). The underground and the DLR make up 11% of daily trips in London for 2017 compared with 35% of trips made by car (Transport for London, 2018c). From 2016 to 2017 complete underground and DLR trips declined by .05% and partial trips declined 1.1% (Transport for London, 2018c). Taxi use has grown in that same year by 2.6% suggesting that some of the underground and DLR decline may be due to more people taking taxis (Transport for London, 2018c). The growth of taxi use is consistent across complete trips and partial journeys at 2.6 million trips yet underground and DLR use doubles from partial trips to complete trips suggesting that people are using taxis for part of their complete trip, to connect to underground stations for the remainder of their journey for example (Transport for London, 2018c).

This is alarming for proponents of rail and sustainable travel if this is the beginning of a trend and a place based transit-oriented development approach may help to increase underground ridership in London again. Until recently the underground system in London has been successful overall with trips growing from 1997 to 2017 by 43% and driving a car for a complete trip has been reduced by 15% (Transport for London, 2018c).

Several studies similar to the research in this thesis have been performed using the London case, focusing on gathering demographic information and performing regressions (Ewing and Cervero, 2010; Goulet et al., 2016). Better connections of public transport and more walking commutes were found to be associated with higher life satisfaction and lower mental distress (Chng et al., 2016). Smart card data is also available for London. As one of the most successful passenger rail transport systems in the world, London is an enlightening case in comparison to newer systems like Los Angeles and Medellin.

This section looks at 20 stations on two lines of the large London transport system, the Overground and the Docklands Light Railway, both peripheral to the core of

London and the London Underground system. Some central stations are included as part of the Overground or DLR such as Bank station and Euston station. Twenty stations were place surveyed and included for a comparison with of passenger rail ridership. These lines were chosen because they have not been studied much before and because they were more similar in place context to stations in the other cities, including Los Angeles. The recently completed but long in fine tuning London Overground runs a periphery service to central London, including serving parts of East London previously poorly connected by rail. From the ridership data I received Canada Water, Highbury and Islington, Stratford, Clapham Junction and Whitechapel are the most used stations of the London Overground. The DLR is a fairly large light rail system that runs through the redeveloped area of the Docklands that is north of central London. The system touches on East and South London and connects to the London Overground, the London Underground, National Rail and the Emirates cable car. Of the different system types that run through London, the DLR is at the low end of ridership but these trip numbers are still very high in the greater scheme of the world's light rail lines. Trip numbers don't compare with the central underground line but they lend insight into this type of peripheral passenger rail system's outcomes.

Figure 63. The London Overground passenger rail system (Transport for London, 2018a).

Figure 64. The London DLR (Docklands Light Railway) passenger rail system (Transport for London, 2018b).

Figure 65. The London DLR and Overground stations surveyed with pins on map (over Google Maps, 2018).

9.2 Place Site Analysis in London

The place site analysis survey of London involved very diverse stations including Bank and Euston which are very heavily used interchanges with more residential stations such as along the Overground and DLR. The Overground and DLR lines were chosen to have a rough comparison with Los Angeles' built environment. The average place score is lower than the median, 30.45 versus 32.5. Again, this means that some high performing stations are pulling the average up but that there are a lot of lower performing stations. No stations were as inhumane as the freeway interchange stations in Los Angeles. Below is a chart showing the range of place survey results.

Table 19. London stations by place survey ranking.

Station Name	Place Survey Score
Canada Water	41
Shoreditch High street	41
Cutty Stark for Maritime Greenwich DLR	40
Greenwich DLR	40
Whitechapel	38
Heron Quays DLR	37
Shepherd's Bush	36
Clapham Junction	34
Canary Wharf DLR	33
Dalston Kingsland	33
Shadwell	32
Highbury and Islington	30
Bank DLR	27
Limehouse DLR	25
New Cross Gate Overground	25
Euston Station	23
Lewisham DLR	21
Canning Town DLR	18
Stratford	18
Willesden Junction	17

9.3 Passenger Rail Ridership in London

The mapping of passenger rail ridership revealed some very high performing interchanges, Bank, Euston and Stratford. Passenger rail ridership has a smoother curve between stations than the Los Angeles cases. Even Bank while the highest is not an order of magnitude larger than any other stations in the city, like Union Station and 7th Street in Los Angeles. However, average ridership was still much higher than the median, 23,355, 126 trips versus 12,575, 834, describing that the transfer hubs were skewing the average with their high ridership.

Table 20. Annual passenger rail ridership of London Overground and DLR stations surveyed.

Station	Passenger Rail Ridership
Bank*	72,768,495
Stratford*	62,305,150
Canary Wharf*	56,608,923
Euston*	40,461,213
Highbury and Islington*	35,646,448
Shepherd's Bush*	34,214,951
Canada Water*	29,952,945
Whitechapel*	22,832,399
Canning Town*	18,877,876
Shadwell*	13,864,077
Clapham Junction*	11,287,590
Lewisham*	9,512,999
Willesden*	9,322,083
Shoreditch High Street	9,000,504
New Cross Road*	8,215,062
Dalston Kingsland	7,515,388
Limehouse*	7,088,816
Heron Quays*	6,609,204
Cutty Stark	5,570,538
Greenwich *	5,447,864
*Rail transfer available	

9.4 Case Studies in London

Place case studies from the London Docklands Light Railway (DLR) and the London Overground station areas are Canada Water, Shoreditch High Street, Cutty Stark, Greenwich. Eight stations were included in the passenger rail ridership case studied for London in order to have a diverse group for both the DLR and Overground stations including, Canada Water, Highbury and Islington, Stratford station, Clapham Junction, Whitechapel, Bank station, Heron Quays, and Shadwell DLR station. Canada Water is discuss for both place and passenger rail ridership. These stations were selected for a diverse sample of the study of London with high ridership and high place quality stations being included.

9.4.1 Canada Water Station

A station with a very high urban design index and high number of trips is Canada Water. The area is a combination of new and old development. The station is located next to a shopping mall but also is on a scenic quay with seating. The surrounding area is characterized with new and sought-after housing with a few extra amenities such as a cinema, a school and markets. The quiet area is contrasted with the busy atmosphere of the station that connects to the Overground, London Underground and several bus lines. The area outside of the shopping centre is characterized by polished contemporary architecture. However, the space is comfortable for pedestrians and bicycle riders due to the wide spaces of the shopping centre and the deck area around the quay as well as some bicycle paths.

Canada Water is a station that sits in Surrey Quays just southwest across the river from the City financial district of London. The Overground line connects to the Jubilee underground line here, as well as to ample bus connections. Canada Water as the Overground station with the highest ridership, located to the City of London office and financial employment centre of Canary Wharf as well as a major transfer to buses that serve the areas of South London that are currently poorly accessed by the London Underground. There is a shopping mall nearby to the station in Surrey Quays as well as large amounts of premium selling homes. Canada Water station shows what development with rail can accomplish, by government plan or market, along with a strategic location. Canada Water straddles the Canary Wharf financial centre and the underserved by transport South London. Also of note, Canada Water out ranks the end station on the Overground line of Stratford.

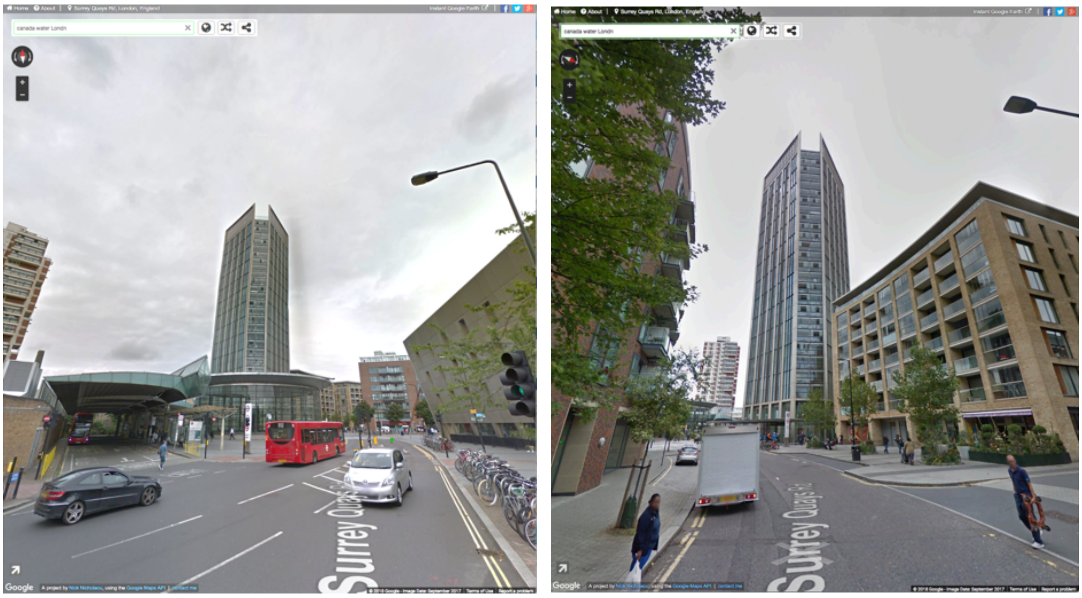

Figure 66. Canada Water station area (after Nicholaou, n.d. from Google Earth, 2017).

9.4.2 Shoreditch High Street Station

Shoreditch High Street’s environment is characterized by large sidewalks and a shopping mall. The station is close to a major city financial area but there are other stations on the underground line that serve the City of London more directly. Yet, there still are benefits from the centralization of business and retail that spread to this area. The station and the plaza have an informal or modest approach to the urban design but there is still place to congregate. The station area has a mix of retail and amenity offerings for travellers without being congested.

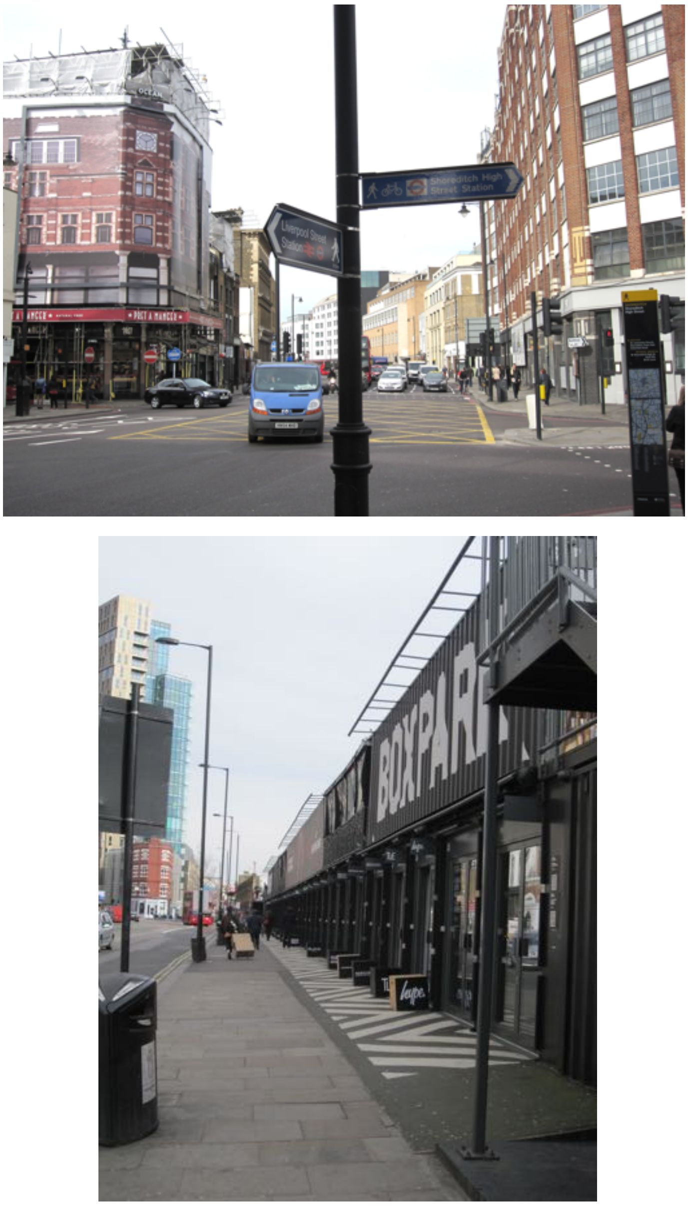

Figure 67. Shoreditch High Street station area.

9.4.3 Cutty Stark Station and Greenwich Station

Cutty Stark station opens into a small tourist and pedestrian outdoor mall with shops and restaurants of the middle and fast food variety. Nearby are cultural and tourist institutions including the Old Royal Naval College. The scale of the area is from another era of passenger train development and oriented towards the pedestrian with several areas closed off to auto traffic.

Figure 68. Cutty Stark for Maritime Greenwich DLR station area (after Nicholaou, n.d. from Google Earth, 2017).

Around the corner from Cutty Stark is the Greenwich DLR station, at another classic type of rail station with a shed entry and trains through the other side. There are snacks and food at the station and the plaza is comfortable for pedestrians. It can be a wait to cross the road. The area near the Greenwich station begins to spread out more than the area around Cutty Stark station. With a college nearby and some hotels and a distance not too far from the tourist centre of Greenwich the station area is calm for pedestrians.

Figure 69. Greenwich DLR station.

9.4.4 Highbury and Islington Station

Highbury and Islington is a station in East London that doesn’t have much underground service and while it has plenty of bus service, buses can get clogged on the narrow streets of central London making for a frustratingly long commute. The station is clearly not dominated by employment traffic and the context describes a situation that is extremely interesting for the possibilities of public transport in general. Residential and leisure destinations seem to drive this station’s ridership. Perhaps, the ridership can be more explained by the overlapping habits of travel to work and travel to leisure. This station’s data suggests that not only employment travel can contribute significantly to ridership numbers. The lack of competing passenger rail stations in the area may also be contributing to the higher ridership of Highbury and Islington. Highbury and Islington is also a transfer hub for the national rail, and the underground which has intense numbers of riders.

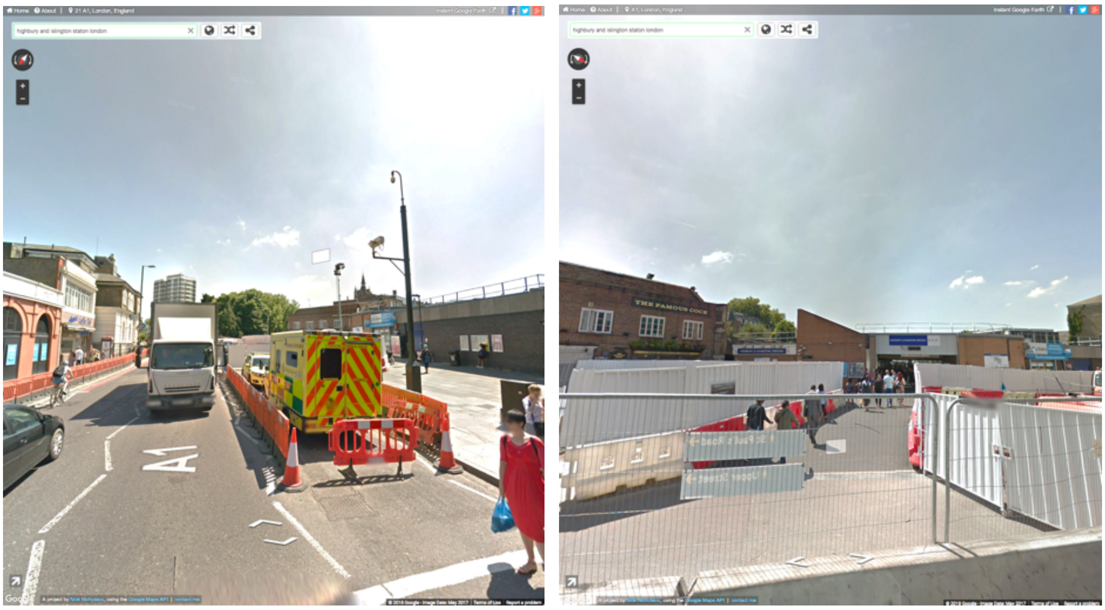

Figure 70. Highbury and Islington station area (after Nicholaou, n.d. from Google Earth, 2017).

9.4.5 Stratford Station

Stratford Station is a grandiose destination on the site of the Olympic village. Ample transport connections including nearly two dozen bus connections, a DLR station, the busy central line underground, an Overground station and regional trains. The exit from the Overground and Underground station deposits travellers onto a small patch of concrete, used for smoking, right in front of the entrance to the shopping mall. Skyways also lead you from the national rail across the road. The organization is reminiscent of airports where travellers are forced to walk through the duty-free section before finding gates. It is similar to Hong Kong stations where property and rail are integrated. However, Hong Kong has more reasons for inward facing developments including extreme weather and very limited outdoor space. Pedestrian space is oriented towards steering people into the mall and periphery sidewalks are not generous.

Figure 71. Stratford station area left, with meagre public space and complicated navigation to rail connections via a pedestrian bridge, compared to the space retail courtyard.

However, the mall Westfield Stratford City is very popular, complete with parking even though Stratford may be the second or third best connected rail station after Euston and King’s Cross. While Stratford Overground station has high ridership, one has to wonder at what cost to pedestrian quality and useful street space. This purpose built condition is a missed opportunity to provide an attractive public space. This luxurious destination lacks similarly generous public space.

9.4.6 Clapham Junction

Clapham Junction is a large station in the southwest of London surrounded by predominantly residential context with a nearby high street and services including barbers, pubs and markets sparsely littered throughout the neighbourhood. The station itself has cafes and sundries but is mostly a very large function oriented regional train interface that has an Overground connection and will have a Crossrail and Northern Line underground connections. The Overground station sits within the larger regional rail junction. Transfers, a somewhat central location and less passenger rail provision on the south side of London account for the high ridership numbers and perhaps a lack of stations and junctions.

Figure 72. Clapham Junction station area.

9.4.7 Whitechapel Station

Whitechapel Overground Station is a similar context to Highbury and Islington, predominantly mixed-use and residential. The area has street vendors as well as the Hammersmith and City Underground line. Whitechapel station is close to a major financial district but there are Underground stations, on the Hammersmith and City line as well, that are closer or in the city that provide for employment destinations. Whitechapel is a station with ridership made from some employment and a rich and active residential and commercial scene.

Whitechapel has a similar context and nearby location to Shoreditch High Street but provides less protection for the pedestrian. However, there are lots of food and commercial opportunities for low-income people unlike near Shoreditch High Street station. There is a busy street market outside the station. The area is interesting because of its largely residential and leisure context as the attractors of people. Wide sidewalks are the only public space but they are active due to the vendors and the bustling residential neighbourhood.

Figure 73. Whitechapel station area (after Nicholaou, n.d. from Google Earth, 2017).

9.4.8 Bank Station

Bank is the DLR station with the highest ridership at 12,440,910 trips per year. It is a terminus for the DLR where passengers distribute to continue their journey. Bank Station is a major transfer station connecting to four busy underground lines and is also a major destination unto itself in the centre of the City of London central financial district. Travel to and from work, as well as transferring, dominate the patterns of movement in this station. While the surrounding area is somewhat mixed-use, the uses cater to the daily workers. For example, it is more likely to see lunch places rather than markets. However, there is a concerted effort to increase housing in the City of London and subsequently more diverse businesses and hours that they are open. Some liveability of these improvements have been noticed since the site analysis of this thesis. The area around Bank is a bit confusing because of the ancient nature of the narrow street patterns. Furthermore, some businesses and malls are inward facing and cater to a wealthy clientele.

Figure 74. Bank station area (after Nicholaou, n.d. from Google Earth, 2017).

9.4.9 Heron Quays Station

The Heron Quays station is located in the heart of the other financial centre of Greater London, Canary Wharf. Canary Wharf is not greatly served by public transport or to the degree that other, older parts of London are and lines like the Jubilee line and the new Crossrail have sometimes overlapping routes. Heron Quays shows the intensity the employment centres can add to ridership numbers as; it is not an end station. There is the possibility to transfer to the Jubilee Underground Line but there is also a transfer to the Jubilee Line at the next DLR station very close by. Yet, this station still attracts 3,236,264 trips a year.

Figure 75. Heron Quays station area (after Nicholaou, n.d. from Google Earth, 2017).

This transit-oriented development station is somewhat awkward at the street level with no crosswalks and a taxi queue but there is lots of foot traffic due to the large amount of office space and some indoor commercial in this Canary Wharf financial district location. Heron Quays had a high urban design quality index and high trip numbers, most likely due to the major financial employment centre it serves. The high urban design score is more for what is available in the area rather than pedestrian access.

9.4.10 Shadwell Station

Shadwell Station is tucked behind the buildings so it does not have great visibility on the high street. There are a couple interesting things that may increase the spread of pedestrians coming out or going into the station. Ample space provides for the municipal bicycles. There is a bicycle lane on a residential street behind the station. The area is mixed residential and commercial.

Figure 76. Shadwell DLR station area (after Nicholaou, n.d. from Google Earth, 2017).

9.5 Comparing Place with Passenger Rail Ridership in London

Passenger rail ridership in London is focused around interchanges and business agglomeration such as Euston station, Canada Water the business centre of Canary Wharf, with some mixed-use exceptions including Shepard's Bush and Highbury and Islington. Bank, the most central station of the DLR and a major employment centre has ridership numbers much larger than the other DLR stations. Canary Wharf, an employment centre also has large ridership numbers with the transfer station Canning Town and end station Lewisham being the other peaks on the DLR line.

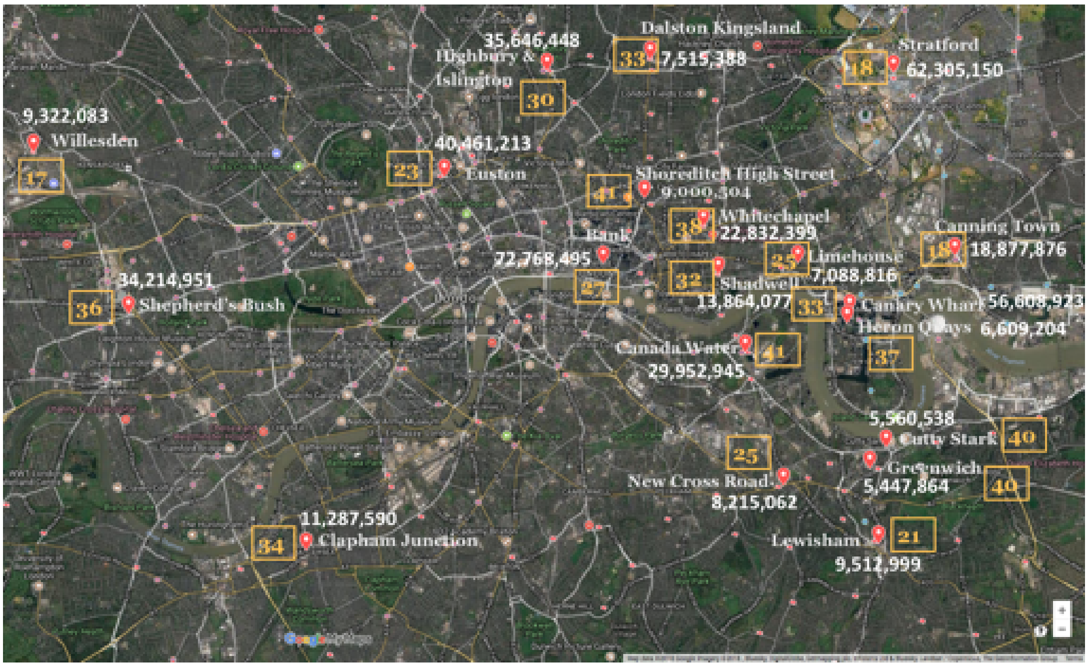

Figure 77. The Overground and DLR stations with rail transport ridership numbers of stations and the place quality survey numbers outlined near their corresponding stations (over Google Maps, 2018).

The main issues of place along the London Overground appear to be an inverse relationship between heavily used environments such as Euston or Stratford and a lower environmental quality. However, Stratford's urban environment is new and there is little excuse for an inadequate place environment. Otherwise, Nascent or historical place quality and existing mixed-use neighbourhoods seem to lag behind stations such as Canada Water that were accompanied with major development investment. The historic and touristic nature of Greenwich outstrips even the quality of the Canary Wharf stations that were accompanied with new built environment developments in and around the station context. Yet, the Greenwich stations have very low ridership compared with this cohort. The Canary Wharf DLR station shows the most coincidence of high quality and high ridership. The following chart shows the spatial organization of place and ridership activity along the London Overground.

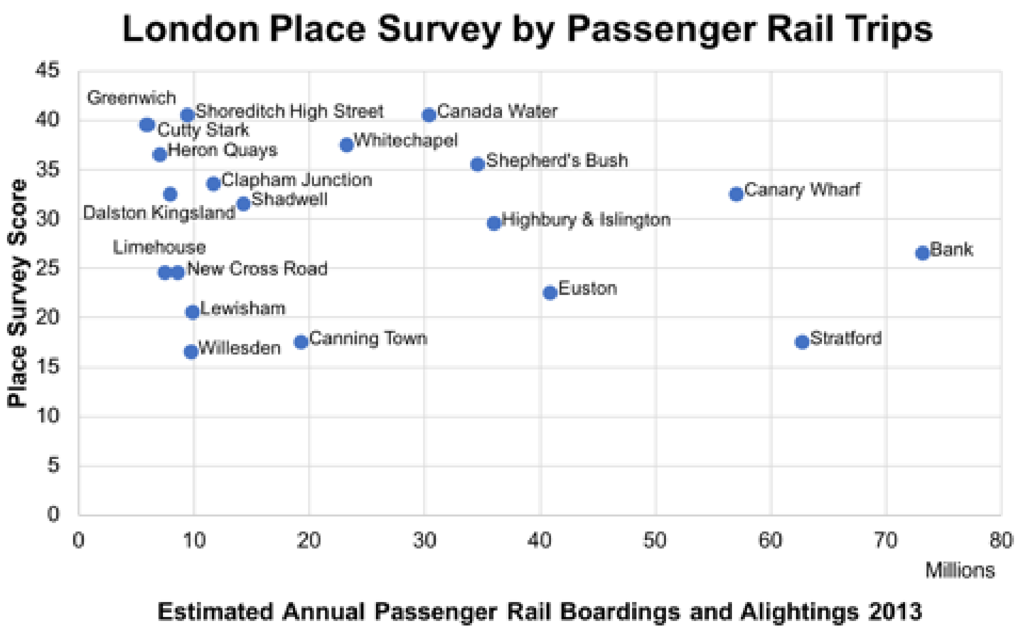

Figure 78. The place quality survey by passenger rail ridership in millions.

10 Medellin

10.1 Medellin Background

The metro system in Medellin is the only passenger rail system in Colombia with 31 kilometres of heavy rail and four kilometres of light rail, while seven cities have bus rapid transit and three cities have cable cars (Velasquez and Hidalgo, 2017). The city of Medellin is the core of a conurbation of at least nine municipalities with the province of Antioquia in the northwest of Colombia (Coupe et al., 2013). Medellin is the only Colombian city to have rail, cable cars and bus rapid transit (Brand and Davila, 2013; Sarmiento et al., 2013). The aerial cable cars were added in 2004 to improve connection to the central passenger rail system (Brand and Davila, 2013). The metropolitan area surrounds the river within a narrow valley that the longer segment of the passenger rail, Linea A, runs through (Coupe et al., 2013; Sarmiento et al., 2013). The now famous low-income neighbourhoods and informally built homes can be seen up the steep hills surrounding the central valley (Coupe et al., 2013).

Figure 79. The Metro de Medellin passenger rail system, bus rapid transit lines and aerial cable cars (Metro de Medellin, 2018).

The cable cars have achieved more attention than the terrestrial systems in Medellin partly because of the accompanying socially beneficial built projects including connections to new libraries and park space (Bocarejo et al., 2014; Brand and Davila, 2013). These transport and social infrastructure projects depend on public and private partnerships (Velasquez and Hidalgo, 2017). Social improvements have been noted in Medellin with transport contributing to income and gender equity (Milan and Creutzig, 2017). During these changes, poverty in Medellin has received a great deal of attention (Brand, 2013). Research on Medellin has shown that well designed transit interventions can make cities more equal and more sustainable (Milan and Creutzig, 2017). Meanwhile new transit-oriented developments have promoted low carbon mobility and improved accessibility (Milan and Creutzig, 2017). Medellin has become an inspiring and popular example of urban change (Davila, 2013).

The Metro de Medellin agency was created in 1979 with construction starting on the system in 1984 and finally opening in 1995, roughly contemporary with the Los Angeles system that recently celebrated twenty-five years of operation in early 2018 (Coupe et al., 2013). The transport agency is owned by the city of Medellin and the province of Antioquia (Coupe et al., 2013). The Metro de Medellin offers an example of how public agencies can be entrepreneurial in that it is self-financing, has operating autonomy and returns those profits to the city for further projects (Coupe et al., 2013). This collection of public utilities, the Empresas Publicas de Medellin, including energy, communications, water and sewage are able to support each other and return surpluses to the city (Coupe et al., 2013).

However, across Colombia as time goes by there is an increase in the concentration of transport investment in urban centres neglecting connections to the periphery and the lower income settlements (Hernandez and Davila, 2016). While urban changes have been beneficial at large. Some groups have paid more of the costs than others by being priced out of their neighbourhoods. A general and even uncontrolled expansion and growth has resulted in a social and economic exclusion with infrastructure only concentrated in central areas (Davila, 2013). This uneven provision of material infrastructures and services is a key tension in transport planning. The recent history of Medellin's transport planning has been a commitment to spatial and social justice and yet caught within neo-liberalism that urges the city to be more internationally competitive (Levy and Davila, 2017). New infrastructure in the city has been concentrated, energising real estate markets, yet failing to incorporate into many local's lives (Brand and Davila, 2013). More so than any other case in this thesis, Medellin embodies a local or informal economy (Brand and Davila, 2013).

Incorporating centralised and fixed infrastructure into local and informal economies is a broad area, rooted in context, that promises fuel for much future research. The transport upgrading of the city has certainly made parts of the city plagued by violence and poverty better through a combined participatory neighbourhood upgrading process including new schools, social housing and enterprises (Levy and Davila, 2017). The aerial cable cars of Medellin are one example of how transport has reached excluded places, previously marked by extreme violence, and now connects them to the central passenger rail system and the urban centre (Davila, 2013). The cable cars provide a promising example of connecting excluded areas to the city but also combining the transport strategy with socially supportive housing and public space projects (Davila, 2013). However, this is often not the case and careful attention is still necessary to ensure these transport investments make the city more socially and environmentally just and more resilient (Levy and Davila, 2017).

Academic or scientific articles remain insufficient on the topic of Colombia and analysis of the effects of transport infrastructure on social life and further research on Medellin and Colombia is necessary (Bocarejo et al., 2014; Lucas et al., 2016; Pojani and Stead, 2017). The story of Medellin's transport innovations and large changes in urban structure has brought international interest including a World Urban Forum in 2014 and many awards (Levy and Davila, 2017; Pujani and Stead, 2017).

Besides Medellin’s transport innovation and agenda at the city level, the national level has policy that reorganizes cities with a population larger than 200,000 people to integrate public transport. Two showpieces of this policy have been the TransMilenio bus rapid transit in Bogota and the cable cars in Medellin with less attention going towards the only passenger rail line in the country (Velasquez and Hidalgo, 2017). Medellin has 27 kilometres of bicycle lanes, far below Bogota (Velasquez and Hidalgo, 2017). Both cities have the Ciclovia pedestrian event yet Bogota’s weekly event is more famous. This pedestrian and bicycle festival takes over main streets one day a week for people to walk, bicycle or otherwise use the streets. This event has inspired similar events worldwide including, Los Angeles’ adjacently named CicLAvia that occurs about five times per year in different neighbourhoods in Los Angeles. Colombia as a whole has 48 million people with 76% living in urban areas with 85% of gross domestic product coming from cities (Velasquez and Hidalgo, 2017). However, passenger cars are only 53 per 1000 people (Velasquez and Hidalgo, 2017). Meanwhile, poverty has shrunk 20% in between 2000 and 2014 leading to a surge in car ownership (Velasquez and Hidalgo, 2017). Public transport use has recently dropped (Velasquez and Hidalgo, 2017). Most public transport use in Colombia is on buses in mixed traffic, many of which are privately operated (Velasquez and Hidalgo, 2017).

The urban rural divide highlights the uneven distribution planning in the country (Ortiz, 2018). The population is centred in a few cities with 95% of municipalities having less than 100,000 people (Ortiz, 2018). At the same time, the 1991 political constitution fuelled decentralised government when the municipality became the unit of government (Ortiz, 2018). The 1994 law 152, required mayors to perform participatory planning in development and is today a part of the intra-national peace process (Ortiz, 2018). Several laws require participatory planning, public participation, local administrative councils and participatory budgeting (Coupe et al., 2013).

The major urban changes after the year 2000 have brought the city out of a dark period of violence, social segregation and economic depression (Coupe et al., 2013). The city government deserves appreciation for the channelling of resources to those that needed them most, reducing violence, providing public transport and generally improving the quality of life (Coupe et al., 2013). Three consecutive mayors have also been key to promoting and fuelling these changes since 2001 (Coupe et al., 2013).

Despite major transport and recent political change achievements, major challenges remain such as how to reduce congestion (Velasquez and Hidalgo, 2017). Congestion costs alone account for more than a six billion United States dollars, or two per cent, of gross domestic product (Velasquez and Hidalgo, 2017). Urban transport accounts for half of Colombia's greenhouse gas totals (Velasquez and Hidalgo, 2017). These totals are partly due to the aging bus fleet (Velasquez and Hidalgo, 2017). At the same time, city centres are changing to tourist areas with population drops in those centres and their periphery (Velasquez and Hidalgo, 2017). Socio-spatial segregation remains high with 18% of the national population living in informal settlements, lacking infrastructure, including transport (Velasquez and Hidalgo, 2017). All of these issues are related and part of transport processes in Medellin. Passengers spend a large share of their income on transport (Lucas et al., 2016). However, bus rapid transit use in Bogota has been low due to the fare prices; a similar effect is likely taking place in Medellin (Lucas et al., 2016).

The city of Medellin remains the exceptional public transport city in Colombia (Velasquez and Hidalgo, 2017). Medellin has been noted for its population's willingness to walk, incorporating active transport into total trips (Marquet et al., 2017). Accessibility and active transport are an increasing priority in Medellin (Marquet et al., 2017). Allying agendas with behaviour patterns may produce positive sustainable outcomes (Marquet et al., 2017). A deeper understanding of the socioeconomic determinants of transport and the importance of accessibility in transport use has been identified as a research and policy need. This thesis' inclusion of Medellin as a case study in its investigation of the relationship between context, both built and demographic, and how those may affect passenger rail ridership is appropriate and has been called for (Marquet et al., 2017).

The system of Medellin does not have the same passenger rail ridership peaks and valleys that Berlin or London have. Linea A has higher ridership than Linea B. The stations San Javier, Floresta and Estadio, are included in the discussion for diversity because the Linea B differs in context from Linea A and provides better urban quality and place case studies. The stations discussed from Linea A are San Antonio, Niquia, Universidad, Poblado, Envigado, Itagui and Parque Berrio. Linea B runs through a more residential area with universities while Linea A has a more industrial and commercial land use, with institutional connections and a central city path.

The Metro de Medellin is consistent in station architecture with virtually all stations elevated high above the street level with plazas constructed below for kiosk venders. Stairs and pedestrian passageways can be lengthy. The system in Medellin is staffed with employees selling tickets and roaming the stations. Many people buy the small paper tickets in batches and lines for tickets are noticeable, even though there are some tap card options. The price for the ticket is high for the incomes of many residents. Trains are very busy at rush hour but passengers are sparse at other times, similar to Los Angeles' ridership behaviour but more extreme. The passenger rail lines Linea A and B run through the centre of the city in a valley along the river. The rail lines connect with the three gondola lines and buses that then spread commuters up the hills or to the outer areas. There are also regional bus hubs that can be connected to from the metropolitan rail. Safety has long been a concern in Medellin but I didn't notice any issues on the rail line, with single women on the trains even at night. However, I did notice armed security at the gondola stations and people hesitant to share gondolas. While the rail stations are new built above ground with a plaza below, there is little transit-oriented development above stations. Derivative development nearby is more likely with the newer streetcar attracting new buildings and development nearby before it is even built.

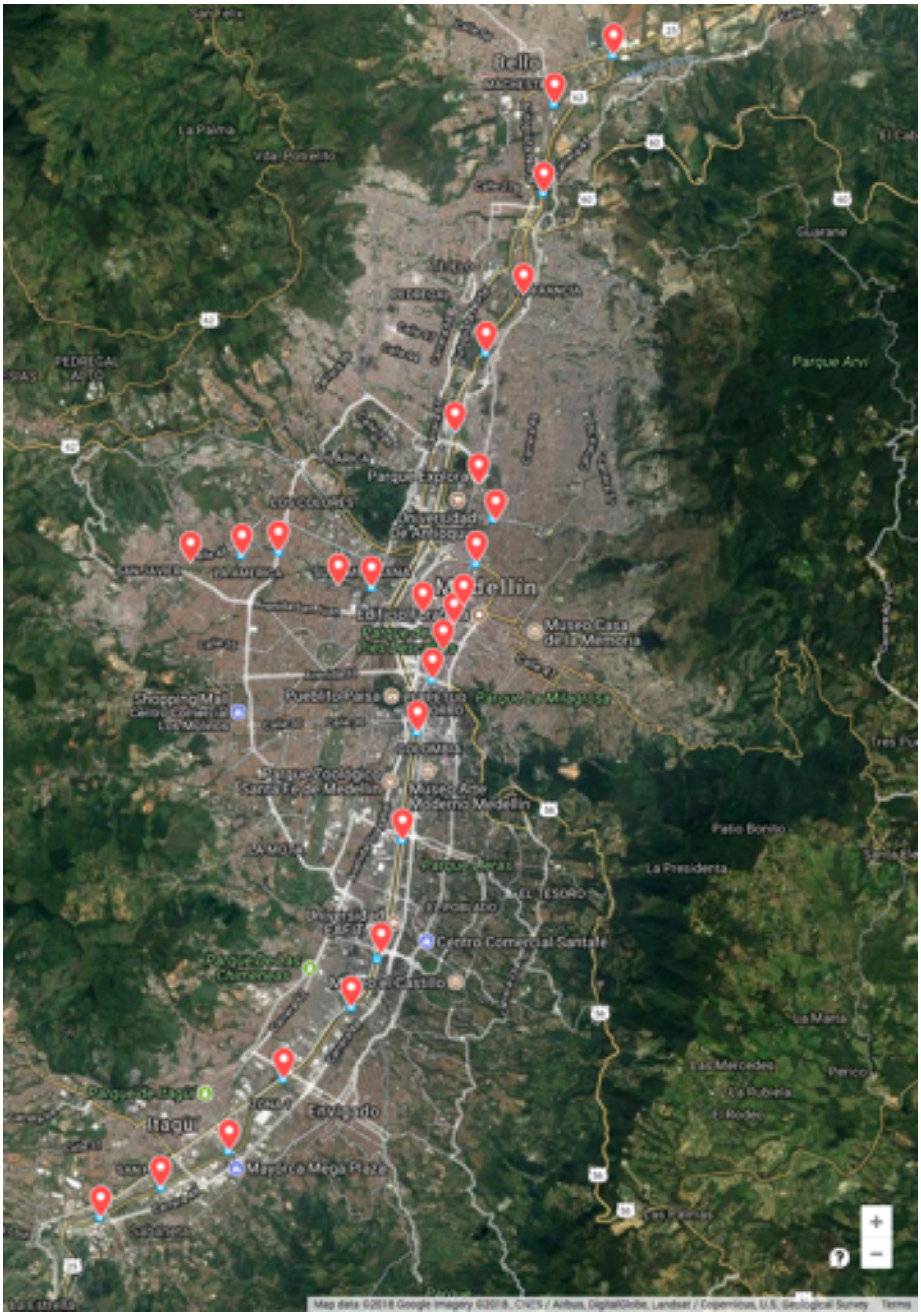

Figure 80. Shows the Metro de Medellin stations surveyed (over Google Maps, 2018).

10.2 Place Site Analysis in Medellin

Much like Los Angeles, many of Medellin's stations scored extremely high on the urban design quality index because of the investment that the Metro de Medellin put into large areas surrounding the station entrances. Most stations have large plazas, vendor kiosks and plantings. In the case of Medellin these station plazas are very large. The stations case studied in this section for place characteristics are Floresta, Santa Lucia, Universidad, Niquia, Parque Berrio, Poblado, San Antonio, Itagui, Envigado, San Javier and Universidad.

Table 21. Medellin stations by place survey ranking.

Station Name	Place Survey Score
Floresta	44
Santa Lucia	44
Universidad	42
Estadio	40
Tricentenario	39
Alpujarra	37
San Javier	37
Expositiones	36
Berrio Park	35
La Estrella	32
San Antonio	32
Acevedo	31
Madera	30
Ayura	29
Industriales	29
Suramerica	29
Bello	27
Poblado	27
Envigado	25
Prado	25
Niquia	24
Itagui	23
Aguacatala	22
Hospital	22
Sabaneta	20
Cisneros	18
Caribe	12

10.3 Passenger Rail Ridership in Medellin

Passenger rail ridership does not vary as much in Medellin as the other cities. The ridership is low compared to the population and performance of the other cities yet, when visiting and using the system, passenger rail ridership seems low in person as well. During commute times, stations, trains and bus rapid transit lines are very crowded with very little standing room. However, outside of commuting hours the passenger trains are not well used. Cost, lack of complexity of the system providing only two arteries of travel and the relative newness of the station with people perhaps still getting used to it may all partially account for the low ridership. Niquia is the highest ridership station and it is an end station suggesting that the line should be extended further in this direction. Niquia's numbers suggest that the commuters are not finished with their journeys. If they were, the ridership numbers might be lower such as in suburban end stations in Los Angeles. From Table 22, light rail line or bus rapid transit line transfer opportunities don't impact ridership significantly. However, perhaps private or informal bus transport networks are more powerful in some ways and are not mapped by the Metro de Medellin. Hospital station connects to two bus rapid transit lines. San Antonio station is the only light rail junction and also connects to one of the two bus rapid transit lines. At the time of this analysis the tram was under construction and did not yet connect to San Antonio station. The two stations that did connect to the cable lines that run up the residential hills are San Javier and Acevedo. Prado and Industriales connect to two bus rapid transit lines, while Cisneros connects to one. However, Prado and Cisneros are towards the bottom of this group of passenger rail stations in term of ridership.

Table 22. Annual passenger rail by station in Medellin.

Station Name	Ridership
Niquia	1,268,752
Berrio Park	977,578
Poblado	910,139
Itagui	795,780
Envigado	771,873
Bello	716,857
Caribe	694,705
Acevedo***	677,798
San Javier***	667,437
Aguacatala	610,458
La Estrella	602,433
San Antonio* (**) (****)	582,057
Industriales**	526,991
Tricentenario	523,665
Universidad	520,821
Madera	515,908
Ayura	511,093
Hospital**	475,052
Estadio	452,441
Floresta	439,229
Expositiones	438,679
Sabaneta	378,762
Santa Lucia	302,141
Prado**	282,833
Suramerica	229,922
Alpujarra	193,680
Cisneros**	120,651
* Light rail junction ** Bus rapid transit connection *** Cable line connection **** Now connects to a tram but did not at the time of analysis	

10.4 Case Studies in Medellin

Ten cases are included in case study presentation in the following paragraphs. Linea A had passenger rail ridership numbers predominantly numbers larger than Linea B. However, the place survey shows that place quality is much higher at the Linea B stations, that run through mixed-use leafy residential neighbourhoods that have leisure institutions and amenities. These stations had a higher environmental quality in general than the Linea A stations. A mix of stations are included, Niquia the end station with the highest passenger rail ridership, Poblado, Envigado, Itagui and Parque Berrio, Floresta, Universidad, Santa Lucia, San Javier as well the one transfer station San Antonio. In Medellin many stations are similar based on their route and new station designs, the northern stations run through communities with large populations, and several of Linea A's stations run through an industrial area and major roads.

10.4.1 Floresta Station

Floresta Station intersects with a street that has many food and service offerings in the middle of a residential area with some hotels. The area is unpolished but has all the basics such as sidewalks and street lighting. Floresta is on Line B, which is about half the size of Linea A, and runs west through a valley of mixed-use and residential expanses. Linea B is also integrated with a green path for a significant segment that adds to the pedestrian ease and quality of the entire line. However, this large green path may be problematic after dark with insufficient street lighting. This leafy and green area has many advantages over Linea A that runs along a fast and wide road through industrial and commercial downtown Medellin. There are also schools, colleges and some universities.

Figure 81. Floresta station area (after Nicholaou, n.d. from Google Earth, 2017).

10.4.2 Santa Lucia Station

Santa Lucia is one stop west of Floresta and is very similar with its leafy mixed-use context. Santa Lucia is less intense but intersects with a high street with many restaurant options. The elevated nature of the Metro de Medellin provides shade in this often hot or wet climate. Again, the station perimeter is unpolished but crosswalks are large and bright and there is lighting, street vendors and plenty of residential commerce in this neighbourhood.

Figure 82. Santa Lucia station area (after Nicholaou, n.d. from Google Earth, 2017).

10.4.3 Universidad Station

Universidad is named for the large university it connects to. A striking elevated station, it sits between a botanical garden and a university with many points of architectural interest. Most of the urban design and quality of the built environment at Universidad comes from the university location with has a wide plaza, luxurious benches and shading as well as a food court and destinations including a planetarium. The university provides the only retail in the immediate area and station area typology is dependent on the major institutions of the area and it is difficult to see what lessons this typology could have for ordinary stations without the large draws of a university or cultural institutions. The area is fairly active with people throughout the large spaces and bus connections are easy to find and catch. There were lots of people around and many bus connections.

Figure 83. Universidad station area.

10.4.4 Niquia Station

Niquia is the northern end station of the Line A with bus transfers and bicycle parking. Niquia is the station with the highest ridership in Medellin with 1,268,752 boardings and alightings per year. This must largely be explained by Niquia as an end station and major bus transfer station. The end stations are where riders come from or return via after the workday. It is reasonable to assume there is a large outlying population that lives in the regions past Niquia. End stations in Medellin are far more powerful in trip numbers than in Los Angeles, suggesting Medellin's system should be expanded until trip numbers drop. This suggests that the both lines should be expanded further to meet passenger rail riders in surrounding areas. San Javier connects to the gondola that goes up into the hillside communities. However, riders have to exit the rail station and board again nearby at the gondola station.

Figure 84. Niquia station area (after Nicholaou, n.d. from Google Earth, 2017).

10.4.5 Parque Berrio Station

Parque Berrio is the second most used station of the Medellin Metro. The station overlooks an historic park that is a strong centre of downtown life. However, Parque Berrio seems a bit unsafe in the way lively cities are. This park is central to many small and large business and historic or touristic amenities of Medellin. Parque Barrio has more trips than the nearby city centre transfer station suggesting the place properties and business are more important than the transfer possibilities in this context.

Figure 85. Parque Berrio station area (right photo after Nicholaou, n.d. from Google Earth, 2017).

10.4.6 Poblado Station

Poblado is station with the third highest ridership on Line A. Poblado is an area with lots of restaurants, tourist amenities and shopping malls. However, most of these high-end amenities are up a steep hill from the station. There is still plenty around the station but the area becomes dramatically higher end as one climbs the hill, or takes a taxi ride up the hill. For example, the popular tourist area of bars, hotels and restaurants near Parque Lleras is over one kilometre away, mostly up hill, and not accounting for detours for a driving or walking route. These amenities were not obvious during site analysis. Still, the entire area to the East of Poblado station is full of business and residences and the larger area of Poblado is known for new development, restaurants and safety which is no small commodity in Medellin. The local Ciclovia pedestrian and bicycle event runs through the Poblado area on Sundays and takes over a major auto artery. A few centres of higher education are near to this metro station. Pobaldo is an area of concentrated wealth.

Figure 86. Poblado station area (after Nicholaou, n.d. from Google Earth, 2017).

10.4.7 San Antonio Station

San Antonio, the only intersection of the lines and a major downtown station that has major peaks in ridership at rush hours. However, San Antonio while being a transfer station and well placed in downtown, does not rank in busiest stations of Medellin. Some reasons for this might include, lack of bus transfers in relation to other stations and less small businesses than near Parque Berrio. Private and municipal buses remain the major method of travel due to the history of Medellin and the flexibility buses offer to travel up and around into residential neighbourhoods. Since the site analysis a tram has opened in 2016 and may be affecting ridership numbers at San Antonio.

Figure 87. San Antonio station area.

10.4.8 Itagui Station and Envigado Station

Itagui and Envigado are both near the southern end of Line A and have similar properties, the dominant aspect of each must be that they connect to the municipalities, or boroughs, of their namesakes. Around Envigado station there are large expanses of parking and residential, with some offices and commercial uses. Itagui has bicycle parking and bus connections. These stations aren't particularly interesting except for the fact that their ridership must come from a largesse of residences that are not near the stations and even may be regional commuter stations. The southern end of Linea A must act more as a dispersed series of end stations rather than passengers dominantly distributing from the final station because Envigado and Itagui as the third and fourth to final stop have higher ridership than the final two. This may also be an expression of the separate density congregations of these separate municipalities that are now merged together spatially and create greater Medellin.

Figure 88. Itagui and Envigado, left to right, station areas (after Nicholaou, n.d. from Google Earth, 2017).

10.4.9 San Javier Station

San Javier is the final stop on Linea B and the only station on Linea B to make the top five busiest stations. At San Javier passengers can connect to the cable car and to many bus routes and types. San Antonio is also very lively with street vendors. San Javier's high ridership suggests that the station is made of many feeder modes of transport as people either disperse from Linea B to make their way home, or join the metro at Linea B to make their way to the city centre or work.

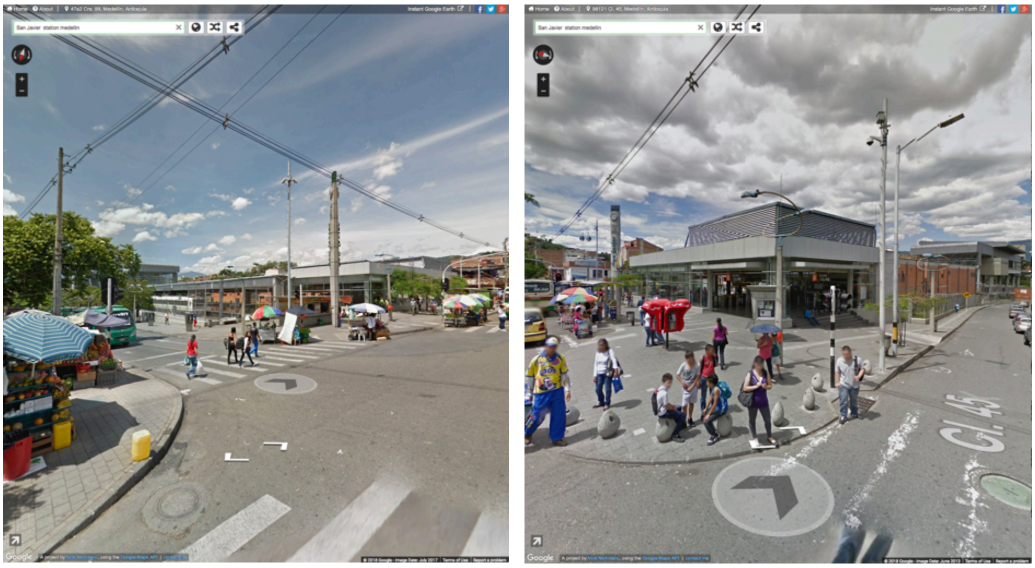

Figure 89. San Javier station area (after Nicholaou, n.d. from Google Earth, 2017).

10.5 Comparing Place with Passenger Rail Ridership in Medellin

Passenger rail ridership in Medellin does not have major peaks and valleys like some of the other cities surveyed, Los Angeles and London for example. The end station of Niquia's performance denotes an irrigation of people to the greater region via the station. Line B has less ridership and while it runs through dense neighbourhoods there is not the employment agglomeration that Line A has. Ridership along the larger Line A must relate to historical residential settlements and current municipalities. The only transfer station between the two lines San Antonio is also much lower than the historical centre nearby named Parque Berrio. A deeper analysis of ridership in Medellin would point to density and historical settlement patterns as these separate areas have grown together to be a large urban spread.

Urban design quality is slightly better around the centre and much better on Linea B which has many public amenities, parks and mixed-use neighbourhoods. Much of Linea A runs along a major auto route with many fast-moving cars, within an industrial area and along a river that all combine to segregate human connection with the street. The long and high pedestrian overpasses that surmount these obstacles are almost as famous as the Metro de Medellin itself. However, the new nature of the stations, implemented with benches, streetlights and vendor kiosks raise the place scale for Medellin along both lines.

Figure 90. The Metro de Medellin stations with passenger rail ridership and place survey results (over Google Maps, 2018).

The average passenger rail trip numbers for these stations is 562,508.7 per year and 29.9 for the place survey. The median scores are almost the same showing little skew, with 523,665 for passenger rail trip numbers and 29 for the place median. The major outlier in trip numbers, and place quality do not distort the curves unlike the other cities. This is likely due to population and employment distribution as well as place quality distribution with most stations developed in the same manner with elevated rail above a large plaza with design investment and amenities. San Javier has a reasonably high urban design quality and about an average ridership level. Parque Berrio is of more interest as it is the busy downtown station in the historic centre, one stop away from the downtown transfer station with above average quality, in Medellin, which has a somewhat high quality across all the new stations. Parque Berrio is also well used. Otherwise in Medellin, it appears that there are as many inverse relationships between quality and ridership as there are coincidences.

The place survey by passenger rail trips in Figure 91, shows the most tightly grouped charting of stations of these five cities. Prado station is a historic core central station that has a possible connection to one of the bus rapid transit lines. The second station, in terms of passenger rail ridership is Industriales that also connects to a bus rapid transit line. Tricentenario is apart from the group in terms of the place survey due to its monumental configuration, over a river and fast street, as well as a lack of integration with pedestrian amenities. La Estrella is an end station and the low ridership may be due to diffuse suburban conditions.

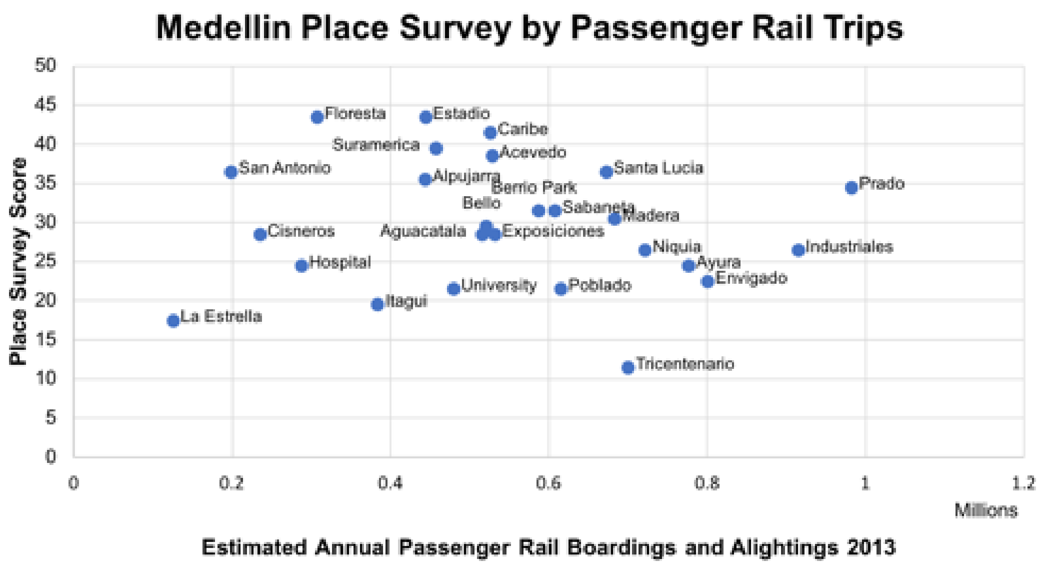

Figure 91. Map of the place quality survey by passenger rail ridership in millions.

11 Triangulation and Comparisons

The previous chapters have provided an analysis of background information, statistical analysis and place site survey mapping for the five cases, Los Angeles, Berlin, Hong Kong, London and Medellin. We have seen how place and urban design attributes interplay with passenger rail ridership in city specific cases. The next challenge is to compare the results of these case studies and search for generalizations that might apply to any case. However, this is a key tension in case study research with results often being non-transferable to other cases while at the same time planners and researchers need tools to move forward (Dieleman and Guillaume, 2002; Ewing and Cervero, 2010; Ewing et al., 2016; Flyvbjerg, 2006). This chapter starts with a background analysis that is a comparative summary or triangulation of the data from each city. Finally, a consensus analysis of all five city cases is condensed to discover the broadest conclusions and make statements of how certain types of stations operate.

11.1 Background Analysis

It is difficult to compare the stations in these five cities exactly because of their varying population size and the formats of data available. However, we can see a few insights from comparing place numbers that might form hypotheses for future research. Berlin and London had the highest place averages owing to historical human scale construction and mixed-use environments that heavy transit-oriented development like in Los Angeles and Hong Kong, and to a lesser extent Medellin nearly approximated. Trip numbers are difficult to compare without population, population density and similar metropolitan boundaries.

Table 23. Case study cities organized by public transport mode share, with population size, area, and population density (Census and Statistics Department, 2010; Eurostat, 2018; ICLEI, 2016; Transport for London, 2017; UN Habitat, 2013; U.S. Census Bureau, 2016). Public transport mode share roughly follows city population density with the exception, London, overcoming Medellin due to its complex public transport system.

City	Public Transport Mode Share	City Population	Greater Area Population	City Area	City Population Density	Greater Area
Hong Kong	**53.8**	7.347			**6300**	
London	**37**	8.136	8.5	1572	**5100**	1572
Medellin	**29.4**	2.46	3.7 - 4	380	**6221**	1152
Berlin	**26**	3.47	3.5	891.8	**3944**	30370
Los Angeles	**5**	3.976	10.17	1302	**2910**	12305
	percentage	millions	millions	km squared	persons per km squared	km squared

Table 24. Transport mode shares of case study cities (Census and Statistics Department, 2010; Eurostat, 2018; ICLEI, 2016; Transport for London, 2017; U.S. Census Bureau, 2016).

	Public Transport Mode Share	City Population	Walking Mode Share	Bicycle Mode Share	Private Car Mode Share
Hong Kong	**53.8**	7.347			
London	**37**	8.136	24	2	37
Medellin	**29.4**	2.46	26.1		
Berlin	**26**	3.47	29	15	30
Los Angeles	**5**	3.976	3	1	85
	percentage	millions	percentage	percentage	percentage

The latest data from the United Nations places the populations of these five cities in order with Hong Kong having 7.3 million people in 2016, London having above 8.2 million people in 2011, Los Angeles having just below 4 million people in 2016, Berlin having 3.5 million people in 2016 and Medellin having over 2 million people in 2005, all measured by city proper boundaries (United Nations Statistics Division, 2018). Judging from population alone it would suggest that average trip numbers would follow a London, Hong Kong, Los Angeles, Berlin and Medellin pattern. Many of these rail lines cross city boundaries into outer areas. A wider boundary of urban area would order population Los Angeles, London, Hong Kong, Medellin and Berlin. However, public transport mode share roughly follows the city boundary population density in order of Hong Kong, London, Medellin, Berlin and Los Angeles arguing for a pro density transport strategy. The key difference is that Medellin has a higher city population density yet a lower public transport mode share than London owing to a greater complexity in the London system, a long history of public transport and disincentives for driving.

However there is more to the public transport story than just population density. Los Angeles has a similar built environment, at least in parts, to many of these other cities, especially Medellin where the public transport mode share is much higher. Furthermore, unpinning the passenger rail trips from this public transport mode share metric tells a different story that upends ordering by mode share, city population or population density. Rail trip numbers reflect a passenger rail plus development strategy that either locates rail where the people are or develops housing and uses near new rail lines.

Table 25. Shows averaged station ridership and the average place score for the stations surveyed by city. For example, the average station ridership in Medellin is 562,509 trips in and out of a station.

Comparisons of Average Station Trip Numbers and Average Place Quality Score					
	Average Station Annual Ridership for Trips in and Out of Stations	Average Place Quality	City Population (millions)	City Population Density (persons per km squared)	Number of Stations Averaged
Hong Kong**	62,632,175	28.93	7.347	6300	15
London	23,355,126	30.45	8.136	5100	20
Berlin*	20,147,108	33	2.46	6221	18
Los Angeles	4,061,570	26.6	3.47	3944	31
Medellin	562,509	30	3.976	2910	27

*Berlin average ridership based on average weekday travel multiplied by 365 for an annual estimate. Berlin numbers include intracompany transfers, 2007. Other case ridership data is from 2013.

**Hong Kong average rail ridership derived from average weekday ridership.

Los Angeles lags behind for a variety of reasons, including the lack of driving disincentives, the relative newness of the passenger rail system and the urban spread of large distances. Still, one could live and work in dense mixed-use areas of Los Angeles and use public transport to or from the historic centre and many other locations. Medellin has similar built environment and cultural issues to Los Angeles, where the population still may be learning to incorporate the passenger rail system into their routines. However, the public transport mode share is substantial and other informal bus or car sharing routines may already exist in Medellin. In Medellin car ownership is growing still and is likely to impact public transport use. Furthermore, several passenger rail stations in Medellin are poorly sited in industrial areas along the river disconnected from housing and retail by large distances that must be surmounted by high pedestrian overpasses.

There may be appear to be a disconnect between passenger rail ridership averages and population or density, but after site analysis, using these systems, identifying scales of distances at the pedestrian level and amenities nearby stations and doing background research on the history of the cities, these numbers have complex yet available explanations. Public transport use is a complex multi-factorial issue.

Background research and site analysis are key to put these numbers in context with these cities' histories, travel behaviour and built environment (Dieleman et al., 2002; Dieleman and Guillaume, 2002; Hernandez and Davila, 2016; Zemp et al., 2011a; 2011b).

Table 25 also shows the average annual passenger rail ridership of these stations surveyed by their average place quality score from the site analysis. Hong Kong's high passenger rail ridership reflects its large and dense population, an intensely mixed-use environment, and a strong transit-oriented development strategy by the MTR. The density and transit-oriented strategy not only put people in walking distance to the MTR system but making driving a private car untenable. London's high passenger rail can be explained by a few things, the long history of public transport, the mixed-use pedestrian environment of many central London places, the high population and driving disincentives such as the congestion charge. In the United Kingdom, 40% of people do not commute by car (Dorling and Thomas, 2016). The greatest users of the underground and light rail lived in London with nine boroughs above 16% commuting by underground or light rail (Dorling and Thomas, 2016). Berlin's ridership performance is interesting because it surpasses the greater populated Los Angeles and approaches the much greater populated London. Other factors such as built environment, density, mixed-use pedestrian-oriented environments, history of public transport use and factors that discourage car use are contributing factors and Berlin will be an interesting case for future study on the relationship between the built environment and public transport.

The place scores, reported by the site analysis, do not match the ridership number hierarchy. At the upper end of ridership, Hong Kong has second worst place survey score average due to urban spaces and elements insufficient for the massive numbers of passenger rail users. London and Medellin have similar place numbers for different reasons. Medellin's place survey reflects the heavy investment of station architecture and urban design elements rather than an integrated approach with a mixed-used pedestrian friendly city. In general from the cases studied in this thesis, place quality does correlate with higher passenger rail ridership except at the vary upper intensity of ridership. At the higher end of passenger rail ridership at stations like Euston in London, a major transport hub, urban place quality shows a decline.

While many people walk in all these cities, especially Medellin, the quality of that experience varies greatly and could be much improved in Medellin. London and Berlin have similar historic urban forms yet, Berlin's place survey score is higher. This identifies that London's place environment could be improved by following the example of the Berlin station areas. Los Angeles has the lowest place survey score and this is partially because of three reasons, the auto dominance on the streets including street widths, the reliance on major freeways as thoroughfares for light rail lines, and finally a lack of consistent transit-oriented development with some intensely developed mixed-use station areas by the LA Metro and with some place well in residential areas and many in conditions inhospitable for pedestrians and mixed-uses.

Passenger rail trips of Hong Kong's central commercial stations far outstrip the trip numbers of the other cities. However, none of these do especially high in terms of place quality while several low trip stations in Medellin and Berlin are very high in the place quality regard. Los Angeles has four lowest place survey results that also happen to have low trip numbers. Towards the top and middle of the chart in Figure 92 there are some stations that balance a high place quality with high ridership including Hong Kong's transit-oriented development, and MTR headquarters, Kowloon Bay. Depending on the priorities of ridership numbers or place quality other stations that satisfy both, to varying degrees, are Canada Water, Shepherd's Bush, Chai Wan, Canary Wharf, Admiralty and Freidrichstraße. 7th Street station in Los Angeles is the highest ridership of Los Angeles with a fairly high place quality. While Medellin's ridership, and population, are lower than the rest of these case Parque Berrio would be the station area with the best place quality for a high ridership return. However, several stations in Medellin along Linea B that travels through a residential area with institutions such as sports facilities have very high place qualities due to the investment by the Metro de Medellin in station architecture and a historic built environment. The strategy here would be to add employment centres or more housing near these stations with ample place quality. The following portions focus on a typological analysis of stations to draw conclusions.

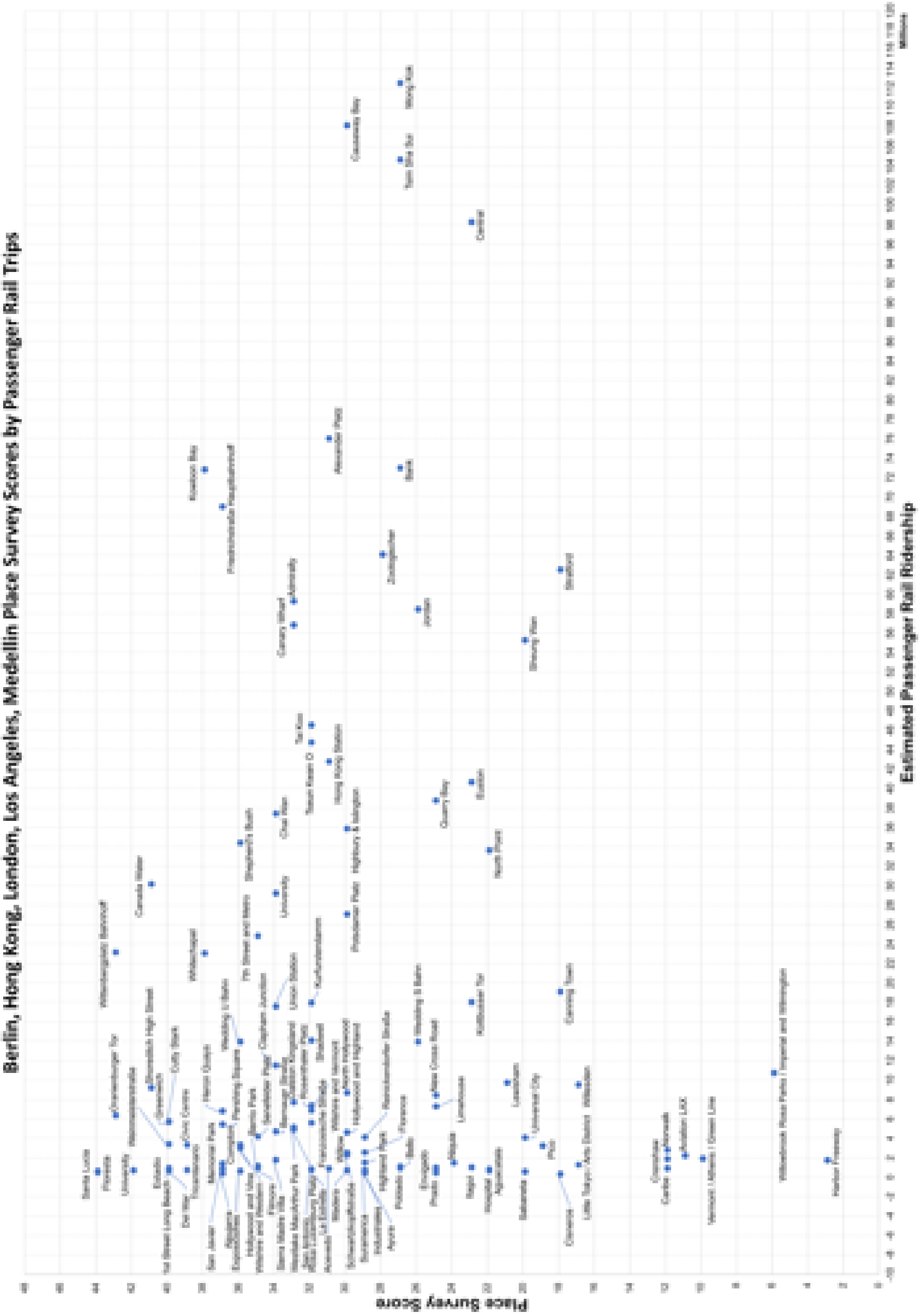

Figure 92. Passenger rail numbers of stations, in millions of trips, by place quality survey score.

11.2 Statistical Analysis of all Cities

The previous sections in this chapter have used a comparative approach and a typological analysis of Los Angeles to put the analysis from the previous chapters in more context. The following is a condensed version of the Los Angeles statistical analysis to, in part, provide a consensus between these five urban cases, Los Angeles, Berlin, Hong Kong, London and Medellin. This statistical analysis was performed in similar steps, starting with identifying correlations through a Pearson correlation analysis of each city individually to determine city specific correlations with passenger rail ridership. A multivariate regression analysis was performed combining stations from all cities, Los Angeles, Berlin, Hong Kong, London and Medellin.

11.2.1 Individual Correlation Analysis of Cities

A correlation analysis was performed on each individual city to find which characteristics of stations or station areas corresponded with higher passenger rail ridership in each city. Data input into the statistical analysis comes from the place survey site analysis and site visits. High values over a .300 are indicative of a strong correlation (Field, 2009). In Berlin, the hauptbahnhof or large transit hub station typology corresponded with higher ridership very strongly. As the number of lines it is possible to transfer to go up, so does ridership. Urban design quality such as trees and plantings and apparent ease for elderly or unskilled users also corresponded inversely with passenger rail ridership in Berlin. In Hong Kong, significant residential nearby corresponded inversely with higher passenger rail ridership suggesting employment or commercial destinations have a stronger destination pull on ridership. London showed that number of transfers available corresponded positively with passenger rail ridership, yet end stations and significant residential in the surrounding station area were negative impacts on ridership. From the site analysis data input into the correlation analysis in Los Angeles, number of transfers available were positive drivers of passenger rail ridership while end stations were negative effects on ridership. In Los Angeles, the end of the line stations are in less dense, more suburban conditions. Finally, the site analysis data that correlated with ridership in Medellin was the appearance of safety in transferring. However, the sum of the social aspects of spaces correlated negatively with ridership in Medellin, suggesting that higher ridership stations did not have amenable social atmospheres.

Table 26. Variables from the site analysis place survey that were found to correlate with passenger rail ridership positively or inversely divided by city. Negative signs show an inverse relationship.

Variable Correlating with Ridership	**Bivariate Pearson Correlation**
Berlin	
Super hub or hauptbahnhof station architecture	0.948
Number of rail lines available	0.756
Plantings and trees	-0.525
Ease for the elderly, differently abled, children or unskilled users	-0.743
Hong Kong	
Significant residential nearby station	-0.537
London	
Number of rail lines available	0.673
End station	-0.603
Significant residential nearby station	-0.634
Los Angeles	
Number of rail lines available	0.867
End station	-0.451
Adequate sunlight	-0.528
Medellin	
Transferring seems safe	0.455
Sum of place survey social aspects	-0.423

11.2.2 Correlation Analysis Combined Model

Under the premise that the inclusion of more passenger rail station cases shows more identifiable relationships, a combined bivariate Pearson correlation was performed on 111 site analysed stations. These stations included the 31 stations surveyed in Los Angeles, 18 examined in Berlin, 15 from Hong Kong, 20 from London and 27 from Medellin. Variables from the site analysis survey and mapping, for a combined 54 variables, were tested against station ridership. This analysis found 13 correlations, both positive and negative.

The strongest positive correlation found was as the number of rail lines, or transfer possibilities available, so did station ridership. Several design aspects corresponded with higher passenger rail ridership in these cities including, the super hub type station architecture with retail offerings and transfers, the convenience of connections and the lack of blank walls. Significant and visible office space nearby also corresponded with higher ridership. Underground rail lines had higher ridership than other configurations such as street level light rail. Two categories from the place survey that coincided with higher passenger rail ridership where the combined factors of issues related to the interactions of modes and the sum of the social aspects of station areas surveyed.

Several inverse or negative correlations were found, included the combined aspects of the station environmental comfort, open and green space, places of shelter, grass as well as plantings and trees. These natural environment factors suffer when passenger rail ridership is higher. There may be less space for green space or the these aspects of the urban environment may exhibit wear after time. This identifies a lack of natural environment at the most used stations and offers a suggestion for improving those station areas.

Table 27. Variables from the site analysis place survey that were found to correlate with passenger rail ridership positively or inversely, considering all cities combined. Negative signs show an inverse relationship.

Variable Correlating with Ridership	**Pearson Correlation**
Number of transfers available	.429
Super hub or hauptbahnhof station architecture	.345
Connecting stops are convenient	.260
Significant office space nearby	.274
No blank walls	.255
Underground and heavy rail	.247
Sum of place survey interaction of modes	.247
Sum of place survey social aspects	.209
Sum of place survey environment and comfort	-.195
Open and green space	-.208
Places of shelter	-.247
Grass	-.248
Plantings and trees	-.254

11.2.3 Multiple Regression on Combined Cases

These 13 identified correlating variables were analysed for their impacts or weight upon passenger rail ridership, beyond their parallel correlating relationships. Seven attributes from the place site analysis survey were found to impact passenger rail ridership in this model, shown in Table 28. The null hypothesis at .000 and the histogram, P-Plot and scatterplot indicate the model is accurate.

Table 28. The part correlation coefficient is used to calculate the singular impact or weight the variable has on passenger rail ridership. Negative signs show an inverse relationship.

Variable Tested Against Ridership	**Part Correlation Coefficient**	**Part Squared**	**Percentage Singular Impact on Variance in the Model**
Number of rail transfers available	.260	.0676	6.76
Super hub or hauptbahnhof station architecture	.183	.033489	3.3489
No blank walls or not a gloomy isolated environment	.127	.016129	1.6129
Sum of the social aspects category of place site analysis survey	.121	.014641	1.4641
Significant office space nearby	.110	.0121	1.21
Grass	-.102	.010404	-1.0404
Places of shelter	-.194	.037636	-3.7636

Table 29. Model summary of multiple regression of place survey and site analysis by passenger rail ridership.

Model Summary	R	R^2	Adjusted R^2	Significance of Null Hypothesis
	0.675	0.456	0.383 or 38%	.000

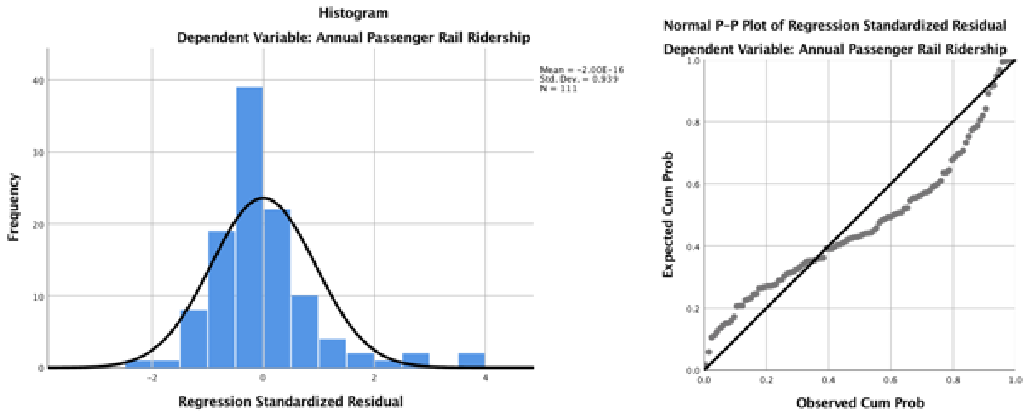

Figure 93. Histogram and P-P Plot showing an accurate, normally distributed model.

However, pulling out significant impacts on ridership from these variables is very small with a station having transfer opportunity being the largest impact on passenger rail trip numbers, at 6.7% weight. These make for large numbers of passenger rail trips. While these impacts also represent a possible opportunity for further research or an expansion of this investigation into place and passenger rail success. The super hub or hauptbahnhof architecture configuration with transfers and retail account for a 3.3% impact on passenger rail ridership. Office space, no blank walls and social aspect quality of space all contributed approximately 1% to passenger rail ridership. Parsing in this way results in a conservative estimates and these singular impacts are likely stronger when combined with others (Field, 2009).

12 Conclusions

The preceding has shown place characteristics effects on passenger rail ridership in Los Angeles, Berlin, Hong Kong, London and Medellin from background, statistical and place site analysis. These conclusions largely match the recent academic literature on the nature of places to public transport use but also offer expansions into areas where our understanding of the relationship of place and public transport are insufficient (Dulal et al., 2011; Pasha et al., 2016). This final chapter presents the conclusions from each phase of research of Los Angeles, the background analysis including the document and interview analysis, the statistical analysis and the site analysis with attention paid to the recurrent attributes of place that affect passenger rail ridership, including density, wealth, quality of area and station, the connecting modes of walking and bicycling, and the architectural or urban design of the stations.

Los Angeles has been the critical case of this thesis due to its diversity of station environments and diversity of station and line configurations. Berlin, Hong Kong, London and Medellin all have aspects for comparisons from similar densities in some cases, to station architecture and technology, to transport agency social strategies and financial operations.

The following chapter begins with the Los Angeles case, presenting the interview and document analysis conclusions, the bivariate Pearson correlations and multivariate linear regression between place and station attributes and passenger rail trip numbers, and the place site analysis conclusions. The other cases, Berlin, London, Hong Kong and Medellin are then incorporated into the conclusions followed by distillation of research gaps that have been filled or addressed in this thesis, opportunities for further research, aspects of this thesis' original contribution and the implications of these results for transport planning, policy and practice.

12.1 Los Angeles Document and Interview Conclusions

1. From a sample of interviews and planning documents, how and to what extent is transit-oriented development included in transport planning in Los Angeles (see Chapter 4)?

Many others have argued that spatial change follows cultural or political movement; the interviews with planning officials and experts in Los Angeles and the examined planning documents to determine the main political agendas in Los Angeles (Ford, 1998; McFarlane and Robinson, 2012; Robinson, 2006, 2011). Dominant identified topics from the interviews were joint land use development, renewable energy and transit-oriented development followed by bicycle planning and density. The most identified topics from the larger planning document analysis were similar, with transit-oriented development, city planning, bicycle planning and renewable energy being vastly more occurring than other topics.

Many topics came up during interviews with planning professionals in Los Angeles including seamless travel, direct routes with heavy and light rail projects as well as projects like street reclamation or bicycle paths. Joint development, encompassing mixed-use housing and developer relationships was the most discussed topic in Los Angeles followed by the environment or sustainability and the closely related topic of transit-oriented development. From the analysis of the planning documents, bicycles were mentioned the most, drawing attention to the need for more research into bicycles, their impact on public transport and pedestrian urban environments (Frank et al., 2015; Frank et al., 2016). Of the 56 terms developed from the 13 interviews, street, rail, development, parking, design, land use, quality, buses, pedestrian, demand, greenhouse gas emissions and road were the terms in the top third of the analysis. Other terms were noted, including car, renewable energy, the environment, walk or walking, density, diversity and transit-oriented development. Urban design only had 11 mentions making it the fifth least mentioned topic, yet virtually all the previous terms are part of urban design or at least have urban design implications (Carmona, 2016). Urban design could even be considered an umbrella term for these topics and considerations (Carmona, 2016).

As mentioned earlier, physical activity of walking trips primarily to public transport have been shown to benefit public health (Boarnet et al., 2013; Hong et al., 2014; Saelens et al., 2014; Spears et al., 2017). Federal funding for sustainable mode transport projects including street reclamation projects for Los Angeles parks, promoted because of their association with physical activity, have been funded by the Centers for Disease Control. Related efforts by the LA Metro in transit-oriented development and mixed-use denser living also highlight the aims of the civic actors in Los Angeles but also the current research advice on the relationship and mutual reinforcement between public health, land use agglomeration and passenger rail ridership (Badland et al., 2017; Boulange et al., 2017; Dulal et al., 2011; Hu et al., 2016).

Aspects of wealth were lightly mentioned in some interviews, including a reverse commute grant scheme that plans for areas of low-income urban dwellers to commute to presumably wealthier suburbs. In general, the LA Metro has planned for and implemented stations in lower income areas for a variety of reasons, some of which include a pro-social agenda, LA Metro property ownership, lower land prices and the fare return from higher ridership numbers. So far, the LA Metro system has expressed what the research says about the relationship between lower incomes and passenger rail use (Boarnet, Giuliano, Hou and Shin, 2017; Dieleman et al., 2012; Farber et al., 2014; Fu and Juan, 2015; Pasha et al., 2016). However, anecdotal criticisms of rail projects of LA Metro and many others have claimed they are contemporary gentrification devices leading to land value increases.

Pedestrian friendly neighbourhoods and bicycle routes were connected to transit-oriented development in the interview outcomes as well as literature review outcomes (Badland et al., 2017; Boulage et al., 2017; Cao et al., 2005; Frank et al., 2015; Krizek, 2003). Bicycles as a connecting mode or primary means of travel were mentioned in interviews and also in plans as a priority. The multi-modal hubs project or the 1st mile, last mile projects were also a topic brought up in interviews and documents that express the importance of connecting modes presented in academic literature as promoting public transport ridership and beneficial health outcomes (Brakewood and Watkins, 2015; Cass and Falconbridge, 2016; Frank et al., 2015; Hopkins, 2017). Included in the multi-modal hubs are electric vehicle charging stations and parking. Parking, or park and ride stations have traditionally been criticised for reduced benefits of public transport (Cervero and Landis, 1997; Dickins, 1999; Parkhurst, 1995; Vijayakumar, 2011). However, in LA Metro planning, park and ride is a necessity in many circumstances. Some stations have parking lots for the short term and long-term goals of mixed-use developments on those sites as behaviours change. The Culver City station along the newest light rail line is also under construction, developing parking into a mixed-use housing development capitalising on the accessible train station.

Overall, the interviews and document analysis identified trends and characteristics of macro level agendas in Los Angeles, including increasing physical activity, developing land use to denser more mixed-use conditions, accommodating lower income passengers and fitting the rail system within an encouraging multi-modal transport network. Smaller scale issues of station architecture and station area quality sometimes were undercurrents or anecdotes of the discussion but were not major apparent themes.

The recurring topics from the interviews and planning document search found that the transport planning agendas, at least roughly, match recommendations from current research on the promotion of connected sustainable modes and denser living, as well as their feedback cycle with greater passenger rail ridership. From these identified agendas, the following statistical analysis found more accurate conclusions on these topics’ relationship with ridership.

12.2 Los Angeles Correlation and Linear Regression Conclusions

2. How are place attributes of passenger rail stations associated with higher passenger rail ridership?
    a. What context or place attributes of a station area, including transport connections, demographics, station design elements and travel behaviour of residents, have bivariate correlating relationships with ridership, in Los Angeles (see Chapter 5)?
    b. Of the correlating relationships found, which have a significant impact on ridership viewed from a multiple regression in Los Angeles (see Chapter 5)?

The statistical research revealed outcomes related to the aims identified in the interview and text analysis. Transit-oriented development, density and connecting modes occurred as topics in interviews and planning documents. Those topics were explored in a more itemized fashion with correlation and regression analysis. Relationships found between factors and ridership fell into themes including, density, aspects of wealth, station area quality, connecting modes and station design.

More detailed conclusions revealed in the correlation analysis were that higher passenger rail use is related to population and housing density in the Los Angeles case. Park and ride stations translated into higher ridership. Meanwhile, wealth indicators including car ownership, owner occupied housing, home value increase and median household income had strong inverse relationships to ridership. Station design elements such as number of transfers available, the super hub station typology and underground line conditions had a high impact on passenger rail ridership. Central location was not studied in quantitative analysis but a metric could be made based on geography or population in later research. These conclusions offer insights into where new lines should be placed or how stations can be designed for a greater number of riders, return on fares, as well as environmental benefits.

12.2.1 Physical Place

12.2.1.1 Density

Density and land use organized in close proximity to passenger rail stations has been studied often in transport research to determine its promotion of ridership with consensus that in general density does promote ridership, with exceptions or nuances possible (Badland et al., 2017; Boulange et al., 2017, Guerra, 2010; Guerra and Cervero, 2011). Zegras found in Chile, that a relationship between population density and land use was not found but commercial agglomeration did have a relationship with ridership (2004). Cervero and Kockleman found that density did not have a strong effect on ridership but did still affect ridership (1997). Residential dwelling density beyond 20 dwellings per hectare along with a well-connected street network, with access to local destinations and short distances to bus services encouraged walking, cycling and public transport use in Melbourne (Boulange et al., 2017). These attributes at the same time discouraged driving (Boulange et al., 2017). It is also possible to design cities without having a trade-off between density and urban green space, attracting more people to the city with trees and green space (Cheng et al., 2017).

In this study of Los Angeles station areas, housing density and population density both strongly correlated with higher ridership of passenger rail. Housing density was more strongly correlated than population density. In Dulal et al., housing density was also found to correlate with higher public transport ridership (2011). In the multiple regression, population density was found to have at least a one-percentage impact on ridership. For example, at 7th Street station, more than 246,169 trips per year are due to the encouragement of density of the station, with resultant air pollution reductions and physical activity bonuses.

Other land use agglomeration factors related to land use including station design of access and egress have been found to relate to ridership (Hu et al., 2016; Metz 2013; Rothwell and Massey 2015; Zegras, 2004). These relationships, as well as urban design or quality in general, were difficult to explore in statistical analysis due to the absence of land use quantitative or qualitative indicators in data sources such as the United States Census. One metric from the Grading California's Rail Transit Station Area's did involve some land use attributes (Elkind et al., 2015). Land use agglomeration factors included in the GCRTSA study include the quality of transit reach and the sum of jobs and households per acre amongst other land use related attributes like walkability (Elkind et al., 2015). The GCRTSA station score correlated strongly with increased ridership and with those that took public transport to work. Land use mixture and urban design aspects are explored further in the site analysis.

12.2.1.2 Station Architecture and Design

Similar to land use and other qualitative factors, station design or architectural factors are not represented very well in the U.S. Census data sources. Mapping stations determined the number of lines or transfers a station had, whether the system was a light rail or underground heavy rail line, and the model or configuration of the station including an at-grade station, an underground station, elevated station or a mega hub condition. Number of transfers was the strongest correlated relationship found with ridership, while the underground line and an underground station condition had strong positive correlations. This is a complex condition because the underground line is also centralised and the second oldest, with other attributes adding to ridership numbers. Similarly, access and egress, as well as station configuration have been studied and found to have relationships with higher ridership (Boarnet et al., 2013, 2017; Metz, 2013; Tabassum et al., 2017). Speed of line has been found to matter in terms of ridership in other studies as was found in Los Angeles with the faster underground line coinciding with ridership (Bernal et al., 2016). Changes in the built environment have also been found to discourage driving (Handy et al., 2005). However, the built environment and station architecture are made from an enormous number of qualitative variables and much more research into them is required. These three factors in the super hub style of station, the number of transfers available, and underground heavy rail translated to a 15% impact on ridership in the Los Angeles case and system context. For a station like 7th Street Station, the mixed-use underground transfer hub, this accounts for in excess of 3,692,545 trips per year. These station design attributes are noted in the site analysis research.

12.2.2 People and Place

12.2.2.1 Wealth

Many indicators of wealth of the station areas surveyed correlated with each other and negatively correlated with ridership. Numbers of individuals below the poverty line correlated strongly with ridership, as did those without access to a vehicle while positive indicators of wealth corresponded negatively with ridership including, owner occupied housing in the area, median household income, percentage of people with two or three vehicles available, how affordable transport was based on income as well as home value increase. Through a multiple regression test, the number of individuals below the poverty line of an area had a one-percentage positive impact on ridership. Although, encouraging low incomes is not a reasonable way to encourage public transport even with environmental benefits, these results can show where new public transport stations should be placed for use and the return of health and environmental benefits. Conversely, home value uplift had a negative five percentage individual impact on ridership. Again, these individual parsed impacts are likely larger in aggregate with other variables (Field, 2009). Transport agencies should be aware that gentrifying areas have a ridership deduction. If the transport agency is responsible for gentrification, and a loss of passenger rail ridership, passenger rail strategies could be self-defeating to a certain extent. Other policies that disincentive car use may help to overcome the negative passenger rail use associated with transit-oriented development urban regeneration.

These results correspond with other research in public transport that shows that higher income people are more likely to use the car than lower income people, in general and car ownership is a major predictor of car use (Dieleman et al., 2002). Reducing costs of bus travel and connecting strategies, including walking, increases ridership (Gong and Jin, 2014; Pasha et al., 2016). At the same time, an increase in fuel prices and tolls would reduce car use, promoting public transport (Farber et al., 2014; Fu and Juan, 2015; Jou and Chen, 2014; Kitamura et al., 1997; Pasha et al., 2016; Pronello and Camusso, 2011; Yao, 2007). Number of workers in a household does not necessarily lead to more car use like car ownership or availability (Dieleman et al., 2002).

Many of these positive wealth indicators corresponded with each other such as, median household income with both driving alone to work and the percentage in the surrounding area of the stations with two cars available. Vehicles available to workers also corresponding strongly with those that drove alone to work as well as other cross-correlations of wealth and driving to work. In short, wealth, including car ownership, corresponds with driving to work in Los Angeles while lower incomes correspond with taking public transport as has been found in many other studies of many other cities (Boarnet and Giuliano et al., 2017; Dieleman et al., 2012; Fu and Juan, 2015; Pasha et al., 2016).

12.2.3 Behavioural Settings, Connecting Modes and Place

12.2.3.1 Connecting Modes

The importance of connecting modes has been found in other studies (Dou et al., 2015; Zhu and Wilson, 207). There is sufficient data of connecting modes from the U.S. Census as well as from the LA Metro to test against ridership statistically. Sometimes, these overlap with station design such as bicycle rack parking spaces available or paid parking places at a station that both correlated with higher ridership. A study in China found that a bicycle-sharing program had an unrealistically large impact on public transport ridership leaving more room for inquiry into the relationship between bicycles and public transport (Brakewood and Watkins, 2015). This suggests that bicycle users do not just translate to passenger rail in an equivalent manner but that attributes of the bicycle realm that are not only translating bicyclists to rail but are further magnifying the use of rail in general. Comprehensive integrated planning with transport infrastructure, land use development and service provision has been shown, and is needed, to create neighbourhoods that support active and sustainable modes of travel and lifestyles based on a flexible mix of land uses and transport options (Boulange et al., 2017). The bicycle user realm metric that judges a station area was found to have a negative relationship with public transport ridership. The bicycle realm and connections with public transport could be a key area for improvement in Los Angeles. In the regression, this negative relationship was quantified as an at least negative 5% impact on ridership. An area that poorly accommodates cyclists, for likely several reasons, also reduces a transfer of people to passenger rail use. Aspects of the bicycle realm may correspond with aspects of the pedestrian realm. Transport policy to achieve sustainable goals must recognize the relationship between public transport and other sustainable modes and counteract negative outcomes through building complementary relationships between cycling and public transport (Dieleman et al., 2002). For example, the LA Metro allows riders to take their bicycles on the trains outside of rush hours and even has special racks on some trains for bicycles. Further drilling down into the variables that make up this metric and the relationship between the bicycle realm and public transport use is necessary and possibly an important new avenue forward in transport studies.

Areas with urban forms friendly to other modes were found to increase ridership in other cases (Cao et al., 2009; Frank et al., 2015). Taking a taxi, motorcycle or other to work was found to have a strong correlation with passenger rail ridership. These are presumably short distance modes people take to passenger rail stations as has been found in many other studies (Cass and Faulconbridge, 2016; Dulal et al., 2011; Handy et al., 2005; Hopkins, 2017). Parking at stations, called park and ride stations, has been a source of inquiry and criticism in research but, in Los Angeles, paid parking at stations translated to ridership (Meek et al., 2011; Mingardo, 2013; Vijayakumar, 2011).

Park and ride associated with passenger rail lines have been shown as counterproductive to sustainable transport goals (Hull, 2005, 2008; Parkhurst, 1995). In Los Angeles, the result that paid parking turns into passenger rail ridership makes the case for a park and ride station's reducing vehicle miles travelled and subsequent pollution as found in the Duncan and Cook study (2014). At least the park and ride stations in Los Angeles are translating to passenger rail ridership, a more sustainable mode, for part of peoples' journeys.

These spatial aspects of connecting modes have been a target of research over the past few decades with areas supporting other modes such as buses, bicycles and pedestrians being connected to public transport success (Badland et al., 2017; Boulange et al., 2017; Brakewood and Watkins, 2015; Cao et al., 2009; Frank et al., 2015; Handy et al., 2005; Krizek 2003; Ksiqzkiewicz 2012). Travel behaviour using connecting modes has also been fairly defined in other contexts as supporting public transport ridership (Cass and Faulconbridge 2016; Dulal et al., 2011; Handy et al., 2005; Hopkins 2017). The results from Los Angeles in this thesis add another layer in supporting these identified relationships and drilling into the relationship of connecting modes and their infrastructure with higher public transport use, reduced vehicle miles travelled and less pollution and public health damage.

Policy recommendations for Los Angeles specifically, include soft measures like walkability in urban design of surrounding areas and hard measures like the introduction of passenger rail line systems for maximum return of environmental carbon emission reductions and to increase walking for public health benefits (Hong et al., 2016). Walkable urban design factors or public transport on their own, also reduce adverse environmental and health effects, although less than a combined approach with sustainable modes supporting each other (Boarnet et al., 2013; Spears et al., 2017).

12.3 Los Angeles Place Site Analysis Conclusions

3. What can site analysis tell us about these station areas in Los Angeles and how does site analysis research complement traditional statistical analysis in transport research (see Chapter 6)?

The site analysis offered many opportunities for research and conclusions that the statistical experiments did not, including exploring human scale aspects like environmental comfort, pedestrian access, social aspects especially perceptions such as perceptions of safety. Land use mixture near stations was investigated in more detail as well as amenities or elements for users such as seating and shade. Statistics is often used in transport studies but care must be taken in data management like normalising or standardizing data, in essence making statistics a study of like things or normal performers, due to the necessity of cutting outliers in order for the model to operate well (Field, 2009). Conversely, qualitative analysis may include all cases, outliers in ridership performance or stations of different typologies. At this pedestrian scale, qualitative analysis conclusions require a case by case, or a station by station presentation of results. In general, the higher quality stations of the survey are not mutually exclusive with ridership even though quality dips a bit in extreme ridership circumstances.

Mapping ridership in Los Angeles correlates with the statistical analysis of Los Angeles in some important ways. For example, the underground line obviously returns more riders, as do transfer stations exhibited by 7th Street station and Union Station. End stations do not have any increased ridership in Los Angeles. Central locations, roughly corresponding with employment centres and density also have substantial ridership numbers. Hollywood and Highland, the mega tourist complex with an underground station, Pershing Square and North Hollywood to a lesser extent also had high urban quality and high ridership showing that mixed-use and transit-oriented developments can provide pedestrian and retail friendly atmospheres while returning high ridership. Tourist areas like Hollywood and Highland or Hollywood and Vine with mixed-use and pedestrian amenities have been promoted as part of a viable economic development in the wake of industrial restructuring in contemporary cities (D. Hall, 2010; Harrill, 2016). Tourism's relationship to transport and as a focus of academic research is insufficient despite offering optimistic redevelopment opportunities (D. Hall, 2010).

Street patterns, road infrastructure and other physical attributes of the city affect the share of bicycle trips in the community area (Pasha et al., 2016; Pasha et al., 2016) In a study of Calgary, green space and semi-detached houses have been found to be associated with bicycle use while number and size of intersections equate with less bicycle use (Pasha et al., 2016). Physical attributes of cities have significant effects on mode shares and the environment and should be considered in planning (Pasha et al., 2016).

However, ridership and poor quality environments were not mutually exclusive either, like Harbor freeway and Willowbrook stations seem to rely largely on transfer bonuses. From mapping and site analysis, agglomeration, development investment, available locations, central locations and the underground appear to drive ridership in Los Angeles corresponding with the regression analysis.

Many anomalous stations were found in the qualitative analysis that are not fully explained through the regression analysis, including predominantly residential areas that have substantial ridership numbers or stations like Compton station that offers a solution to suburban rail implementation. Some central stations along the Purple Line underground line were unremarkable compared to the Red Line's ridership, despite Purple Line stations being located in dense residential and employment centres in the middle of the city. Wealth in these areas may be an overriding negative.

MacArthur Park and Civic Center stations on the Red Line, while central, did not exhibit ridership numbers similar to adjacent central stations and from site observations this could be because of bus competition and plentiful bus transfers available at these stations. The 1st Street station in Long Beach has an overlap of tourism and employment destinations but also ease of parking, and a lack of public transport complexity making for very low ridership numbers. Del Mar Station transit-oriented stations in Pasadena, despite heavy investment, has unimpressive ridership returns. Pasadena is also easy to drive within and an area with wealthy residents, both that may be reducing ridership at these locations.

12.3.1 Place Site Analysis Relationships with Station Ridership

Charting the place site analysis survey results by station passenger rail ridership numbers revealed negative correlations between the environmental comfort attributes as well as social aspects. Positive relationships with ridership from the place survey included built or planned aspects of the station, including how well the other modes interacted as well as the built environment elements, including seating, signage and a well-maintained area.

12.3.2 Los Angeles Typologies

An analysis of destination typology revealed that station areas with predominantly employment centres were the most used passenger rail stations, followed by predominantly residential station areas, and lastly station areas with equal mixtures, in the Los Angeles case. Comparing transit-oriented investment with a non-development station location strategy, the placement strategy actually had the higher trip numbers by an average one million trips in Los Angeles. However, the transit-oriented development strategy had higher place quality scores in from the place survey and the GCRTSA survey in similar ratios (Elkind et al., 2015).

This thesis posited three other types to be added to the GCRTSA categories, the civic station type, the tourist destination type and the super hub type of station. Tourist areas have been named a promising strategy for planning regeneration and likewise deserve more attention in transport planning (Harril, 2016). The super hub typology, nearly a transit-oriented development as destination itself, came from an analysis of passenger rail station ridership behaviours. The stations in Los Angeles, when organized subsequently by ridership have one curve of a slope while Union Station and 7th Street station break that smooth curve with a nearly 50% jump in ridership from the third highest ridership station. These transit hubs, with mixed-use retail and many rail transfers available appear to operate differently and are identified as special cases apart from the rest of the group. These types were also mapped and show a deficiency of stations across the west side of Los Angeles, and with transfer stations rarely available outside of downtown Los Angeles. Complexity, including transfers and overlaps, is a key indicator of whether a system will satisfy in terms of fare returns and perform financially (Cervero, 2002, 2007; Cervero and Guerra, 2011). This mapping also showed the majority of station areas of predominantly employment surroundings as concentrated in the historic centre of Los Angeles but, again, the passenger rail system ignores whole areas of the city.

This typology study shows that there are different components of station types, including the land uses of the surrounding area, the station architecture or configuration, as well as the behaviour or outputs of the station (Elkind et al., 2015; Hawkes and Sheridan, 2009; Kamruzzaman et al., 2014; Payton and Hawkes, 2013). Of course, these different categories or typologies interact within each other as well. More detailed analysis of typologies, separately and in combination, are needed to understand transit-oriented development (Payton and Hawkes, 2013).

12.4 Place and Passenger Rail Ridership for Berlin, Hong Kong, London and Medellin Conclusions

4. With the site analysis approach developed in the Los Angeles case, are there similar relationships between station area design attributes and passenger rail ridership evident in Berlin, Hong Kong, London and Medellin (see Chapters 7, 8, 9 and 10)?

While without as much data for these four cases, the research models including the place survey and the statistical experiments revealed several insights. The first come from comparing these cases to each other and noting how they are different or similar.

The context of Berlin was largely ad-hoc, mixed-use and overlapping with a pedestrian friendly urban condition. However, there were some physical challenges of integration between streetcars, underground and S-Bahn systems despite universal transport passes. Passenger rail ridership and place quality were fairly distributed throughout Berlin yet, ridership was much larger at interchange hubs Alexanderplatz, Zoologischer and Friedrichstraße Hauptbahnhof. However, the place survey and passenger rail ridership didn't reveal correlations especially but quality and trip numbers were also not mutually exclusive.

Hong Kong's environment ranges from an intensely metropolitan yet disordered urban condition to overtly planned station developments with pedestrian skyways and inter-building corridors separate from the street level. However, Ridership in Hong Kong was focused around the central shopping areas more than hubs or deliberate transit-oriented development. Areas with more pedestrian freedom happened to have higher passenger rail ridership in Hong Kong. In Hong Kong passenger rail ridership was focused in the central shopping and employment areas while the more designed transit-oriented developments were higher on the place survey.

Kowloon Bay station had both high ridership and a high place survey score even though it is an outside of the central area. Kowloon Bay is an interchange station with a focused rail and property built environment. Hong Kong overcomes the trend of interchanges or hubs overwhelming passenger rail ridership because they don't have many interchanges and ridership is focused in central shopping areas instead of hubs. This suggests that Hong Kong planning might better focus on creating areas more similar to Hong Kong central areas, or connections to those areas, rather than, or in addition to, their more heavy and traditional transit-oriented developments. Interchanges don't seem to be especially significant to Hong Kong's passenger rail ridership phenomenon. These suggestions should be balanced with the Hong Kong MTR's lucrative property development schemes that are a large portion of their funds. Compromises might include transit adjacent properties developed by the MTR with more street oriented retail, development of areas that mimic central area shopping districts or by providing more connections to those areas. Hong Kong's transit-oriented development and property income is an advantage that could be increased in Los Angeles and is largely missing in London, Berlin and Medellin.

London's context was similar to Berlin's but with hubs drawing passenger rail ridership more noticeably. London's place survey and passenger rail ridership relationship was strongly inverse with small Greenwich stations, and the newer developed Canada Water station. Bank Station and Euston Station were higher in passenger rail ridership but had lower place survey results due to the wear and congestion at these stations. This might suggest that some place embellishment or an urban design strategy should be reincorporated into these highest ridership stations. Another strategy could be to offset passenger rail ridership with nearby hubs or complementary routes around these burdened stations which may prove beneficial to transporting people as well.

Medellin as a city is more like Los Angeles but with a predominantly elevated passenger rail system and little direct transit-oriented development. This presents challenges for catalytic development that depends on attractive private capital. Medellin's place survey and passenger rail ridership mirrored some behaviour from the other cities, with lower ridership stations of Linea B having higher place survey results through the residential mixed-use neighbourhoods and a slight increase in place near the centre of the city on Linea A. Similar to Hong Kong, the historic central shopping area of Parque Berrio has much higher ridership than the nearby San Antonio station that is the only interchange between the two passenger rail lines. The new build elevated stations with the plazas below offer well used public spaces. Medellin has little to none accompanying transit-oriented development by the government and relies on catalytic real estate effects and some incentives for developers near stations. There were few interchanges to study and ridership was focused on the central employment and retail area, as well as some of the northern community stations including Itagui and Niquia showing that these areas could be expanded to have more transport opportunities.

12.5 Case Study Comparisons

12.5.1 Background Comparisons

These five cities in perspective ranked by population size are Hong Kong, London Los Angeles, Berlin and Medellin yet their passenger rail trip numbers tell a different story. In order of descending rail trip numbers the city case studies are Hong Kong, London, Berlin, Los Angeles and Medellin. The place site analysis revealed an even different order with Berlin, London and Medellin being the highest place quality performs followed by Hong Kong and Los Angeles. While high place quality in the case of Berlin and low place quality near stations in the case of Los Angeles may partially explain this swap in order, place quality in Medellin is not an excuse for the depressed passenger rail trip numbers. Hong Kong and Medellin stations overcome the transfer station advantage with their commercial centres having the highest trips numbers of these stations surveyed.

12.5.2 Statistical Analysis of Combined Cases

From the place survey and site analysis, a multivariate linear regression of all station cases, from all five cities, showed that the number of rail transfers available had a 6.76% impact on passenger rail trip numbers, nearly exactly the same as the Los Angeles case that showed that as transfer possibilities go up, so does ridership by 7%. The model of station, or the super hub typology was a less powerful force on trip numbers when expanding out of the Los Angeles case explaining 3.3% of trip numbers for all cases, rather than 7% in the Los Angeles case. The super hubs in Los Angeles, Union Station and 7th Street far outpace the other stations but in the other cities like Berlin, Hong Kong and London, that is not as much the case. Environmental factors such as significant office space nearby had a 1% singular impact. The sum of the social aspects category including feelings of safety and other people present in the space had a 1.46% singular impact on passenger rail ridership variance in the model. Statistical analysis generally becomes more accurate with more cases (Field, 2009). These identified variables that explain the variance of trip numbers also touch on the typological categories analysed in the typology section. The three categories explored in the previous typological analysis were station type, land use and the urban design of the station.

12.6 Gaps Filled

There is an urgent need to predict the transportation policy and investments effects of the dynamics and magnitude on behaviour change (Boarnet et al., 2016; Spears et al., 2017). Further analysis and more tools have been called for by various academics to understand the relationship of user experience and neighbourhood place in transport planning and for transit oriented urban and regional development (Cervero and Guerra, 2011; Guerra and Cervero, 2011). Aesthetic and experiential aspects of urban design and urban amenities are especially in need of quantitative models of understanding and argument (Bertolini, 1999; Bertolini et al., 2012). Further classification of stations and their attributes has also been expressed as a need for further research in transport planning, particularly for evaluation of stations and to add more aspects of pedestrian access (Hickman et al., 2015; Schlossberg and Brown, 2004; Vale, 2015; Zemp et al., 2011b). This thesis attempts to do both by expanding previous models' use of variables, in particular by adding qualitative findings from an experiential site survey into the quantitative statistical model, while beginning a discussion on when qualitative or quantitative research might be more appropriate.

12.7 Further Research

From the tiered statistical methods used in this thesis, there are still many questions yet to be asked about qualitative and quantitative inquiries in transport planning. Firstly, more understanding of the relation between aesthetics or quality and planning projects because the statistical correlations herein have a hard time pinpointing relationships beyond a negative correlation between pedestrian access and passenger rail trip numbers. This conclusion could also be narrowed down further into thresholds where the heavily used stations begin to adversely affect pedestrians and their realm. Further itemization is necessary to study and possibly determine thresholds of the variables', in the statistical analysis, relationships with encouraging or prohibiting ridership.

The census data does not have enough information on the built environment but is also one of the only legitimate data sources on the public realm. Some census indicators such as employment, number of firms available in an area, housing units in the area and density are place indicators and have been discussed within this thesis. More detailed or itemized versions of these indicators would be helpful. More refined land use categories would also be useful, with some categories for history, beauty or quality, even usefulness rather than just the use of commercial, residential etc. We know a lot about these station areas from census data in Los Angeles regarding ethnic or racial components, general income levels and how people get to work, however some of these demographics did not connect with ridership outcomes in the Los Angeles context. A study incorporating distance, focused on pedestrian travel limits, into the statistical analysis would also be interesting to judge catchment areas especially in comparison to different cities and neighbourhoods.

Vacant housing in Los Angeles has a positive relationship with ridership seems counter to the relationships between housing and population density's positive relationships with ridership. This could have an easy answer, such as vacant housing equalling new developments or investment attracted by the stations. However, it will require more site analysis and interviews at least. Unfortunately, this could be related to gentrification. While amelioration of blight is in most transport agencies' agendas, it is a fine line between pushing out the people who might use the passenger rail and having a positive impact.

User aspects such as socio-demographics affecting public transport were unclear, including relationships between female users and adults, while household size and income had mixed relationships with ridership in a study of 185 community areas of Calgary, Canada (Pasha et al., 2016). Los Angeles has a wealth of ethnic and demographic data from the United States Census however, those connections were unable to be made through the statistical analysis of his thesis and it would be interesting to see if another attempt could identify relationships between demographics, beyond incomes, and public transport use.

Other topics that the interviews illuminated were the entrepreneurial attributes of transport agencies, identifying their business strategies to earn income in order to further develop more transport or real estate. How these attitudes affect the materialisation of project types would be an interesting path for future research.

The purpose of this research is to provide evidence for which characteristics of a location, setting or context, promote passenger rail travel behaviour under the presumption that rail travel is better for the environment than the current dominant use of the personal automobile. The major laboratory for this study is Los Angeles, California in the United States with analysis on Berlin, Hong Kong, London and Medellin that might suggest further research on them, in the more detailed manner that was performed on Los Angeles.

12.8 Original Contribution

- Understanding User Experience and Public Transport

  A greater understanding of the user experience, particularly the pedestrian experience has been identified as needed in transport research (Camacho et al., 2016; Peek et al., 2006). The place site analysis survey of this thesis involved site visits as a pedestrian and catalogued urban design elements that affect their experience. This labour intensive, and qualitative, method has not been used commonly in transport research (Gaber and Gaber, 2007). Very few studies of the built environment have included streetscape features (Ewing et al., 2016). The place survey involves more included streetscape elements than Ewing et al. and also updates classic, field defining studies by Whyte by incorporating more environmental attributes of station areas and by translating these attributes found their qualitative methods into a quantitative statistical analysis (Ewing et al., 2016; Whyte, 1980, 1988).

The interaction of other modes with passenger rail use have also not been studied sufficiently, including the unmet need for walkability and the relationship of cycling and cycling environments to rail use (Frank et al., 2015; 2016). This place survey of this thesis advances an understanding of pedestrian environments while the statistical analysis includes the bicycle realm quality and infrastructure (Ewing et al., 2016; Frank et al., 2016).

- More Place Variables and Cases Needed in Assessment Models

More quality of place, urban design, performance and context indicators have been called for many times in transport planning research (Ewing et al., 2016; Papa and Bertolini, 2015; Kamruzzaman et al., 2014). The place survey and statistical analysis have both added more variables to the study of place and its relationship to passenger rail use including user level streetscape elements and station attributes into analysis. More variables beyond previous studies has been used in the preceding analysis, particularly from site analysis, context data and transport station types (Duffhues and Bertolini, 2016; Bertolini et al., 2012).

This thesis includes five case study cities. Very little research is available on passenger rail in Los Angeles or Medellin and this thesis works to rectify that omission in transport planning research (Davila, 2013). Most transport research on Los Angeles has been on the automobile network while most research on Medellin has been on the aerial cable cars (Boarnet et al., 2016; Boarnet and Crane, 1997; Davila, 2013). Comparisons in transport planning case study research have been particularly hindered by a lack of standardisation in data from place to place (Frank et al., 2016). This thesis compares these five cities in a standardized with the place site analysis survey and subsequent mapping, charting and bivariate correlations and multivariate linear regression. This thesis also tracks differences in relationships between context predictor variables with passenger rail ridership and their variances by city and system discussed in Chapter 11.

- Understanding the Interaction and Complexity of Predictor Variables

How context or place plays a role in transport as well as a more human scale of inquiry have been particularly identified as areas of needed growth in transport research (Papa and Bertolini, 2015; Zemp et al., 20111). This thesis has largely focused on incorporating place specific components into analysis. A more complex understanding of variables, including place variables, have been called for including their behaviour and relationship with other predictor variables (Cervero and Guerra, 2011; Duffhues, 2016; Harding et al., 2013). The multivariate linear regression advances the understanding of predictor variables by identifying their singular impact on passenger rail ridership. Furthermore, Table 6 shows cross-correlations of predictor variables identifying relationships.

- More Progress in Assessment Models

The analysis of this thesis has moved towards assessment, advancing research that has previously identified relationships between land use and place with passenger rail (Elkind et al., 2015; Bertolini, 1999). The node-place model has been used to study the balance of development by transport in transport station areas (Bertolini, 1999). However, the expansion of this model and moving the model towards an assessment model rather than a descriptive model has been discussed many times (Bertolini et al., 2012; Chorus and Bertolini, 2011; Papa and Bertolini, 201; Peek et al., 2006). The statistical analysis in this thesis is an advancement because it measures the weights or impacts that context features, or place, has on passenger rail transport rather than just their proportion to each other.

The GCRTSA studied measured the relationship of land use with passenger rail, the analysis in this thesis presents three more types beyond employment, residential and mixed land use contexts of station areas (Elkind et al., 2015). This thesis presents the tourists station area, the civic station area and the super hub transit stations as useful typologies for the study of passenger rail station behaviour. The typological study also combines previous ideas typology study categories of transit-oriented developments, namely the combination of station are or land use types, the station architecture type and finally an awareness of station behaviour or performance itself, all as categories to be included in typological analysis of passenger rail (Hawkes and Sheridan, 2009; Payton and Hawkes, 2013).

- Policy Barriers Identification

The gap between policy and reality has been difficult to understand in transport research, however in the typology chapter of this thesis, it has been shown how transit-oriented development compares to ridership numbers in Los Angeles and that a location strategy is more effective, or at least a combined location plus transit-oriented development strategy (Duffhues, 2016; Elkind et al., 2015).

12.9 Implications for Policy and Practice

From the evidence of this thesis there several key practical tactics that city planners can use to increase passenger rail ridership, for environmental, social and economic benefit as well as reduced auto congestion. Investment in a system with more transfers and more complexity is key for increased ridership (Cervero and Guerra, 2011; Guerra and Cervero, 2011). New systems, like Los Angeles' and Medellin's will also have increasing benefits of fare recovery and time-savings as the system expands (Cervero and Guerra, 2011; Grube-Cavers and Patterson, 2015). Los Angeles' and Medellin's systems are still in an initial phase of investment but will begin to mimic the fare recovery rates of other large dense American cities (Cervero and Guerra, 2011). A threshold of accessibility before transport investments become profitable, along with increased ridership, is nascent in burgeoning transport systems (Cervero and Guerra, 2011).

An underground fast moving system that bypasses street intersections is also important (Bernal et al., 2016). Paid parking and bicycle parking should be provided and more attention paid to the cyclist experience in connection to passenger rail. Taxis, motorcycles and other connecting forms of transport should also be encouraged in Los Angeles (Brakewood and Watkins, 2015). Investment in the connecting modes such as bicycles and taxis will have benefits for public health and the environment whether or not people use them to connect to passenger rail or for their entire journey. In the case of Los Angeles, terminal stations should be reduced, or accompanied with denser development because terminal stations in Los Angeles are providing low ridership. Another strategy would be to implement an orbital route, similar to the London Overground, that connected outlying stations with sub centre connections.

New stations or lines should be placed where people will use them and in the case of Los Angeles this is in the lower income neighbourhood that have significant density of housing and people. Denser housing should be encouraged. However, strategies to encourage middle and upper income earning people to use public transport should also be used. Improvements in service, access, quality and frequency would increase public transport use (Pasha et al., 2016). While some of these correspond to traditional thinking, after quantification, costs and benefits can now be calculated in future steps. The statistical model offers a tool for further quantification of passenger rail stations, particularly concerning place attributes and user experience. The exact relationship between these interventions and the costs of the intervention unclear. Now that these relationships have been identified and quantified cost benefit analysis can be performed on individual or combined variables. All of these points made provide jumping off points for future research on public transport and how place contributes to transport success.

12.10 Summary

This thesis identifies predictor variables of ridership are in Los Angeles for more accurate transport planning that further diminishes pollution and incorporates physical activity into travel. This thesis has also presented the different conclusions that different methods lead to. Qualitative research including mapping has been said to fill gaps in quantitative methods (Bakogiannis, 2014; Clifton and Handy, 2003). Qualitative methods also offer a different scale of inquiry including user experience and investigations into pedestrian comfort (Hickman et al., 2015; Ksiqzkiewicz, 2012; Lucas, 2013; Mars et al., 2016).

The place site survey of this thesis was an analysis of urban design attributes at the pedestrian scale to identify and understand their impact on ridership. Fare returns are an economic motivator for public transport investment and this research is an effort to argue for more public transport investment while fine tuning station elements and strategies for greater returns of riders as well as environemntal and public health benefits. While pedestrian access and travel was found to have a small relationship with ridership, it seems unclear if quantifying qualitative data is really the best way to incorporate qualitative data into transport research. Grading stations to recommend improvements may have impacts on perceptions once improvements are complete but a further study in this vein would be to poll users' perceptions against ridership rather than actual urban design elements at stations. Furthermore, ridership in Los Angeles has such as strong connection with lower income people who may not have enough economic power to change their travel patterns even if station areas are unpleasant or hindered pedestrians. Another next step would also be to measure adjacent stations, for example if one had a passenger drop off or was safer or better lit, perhaps ridership could be seen to move towards the more amenable station. A more detailed comparison in the next steps would compare like stations, and see which did better ridership and why.

Qualitative research does allow us to criticise quantitative research for what it does not provide, namely the United States Census data, amongst others, has virtually no information on the built environment. Mapping of sites such as parks, parking lots, historic sites must supplement demographic data from the U.S. Census and cobbled together with health and pollution data from other sources in order for relations to be made. Many of the most important factors in public transport are not included in United States Census data including walking and high-quality mixed-use environments have been related to positive public health outcomes from walking and lower pollution atmospheres (Boarnet et al., 2016; Cass and Faulconbridge, 2016; Hong et al., 2016; Jabareen, 2007; Spears et al., 2017).

Statistics is the study of like cases and intensive data management must be done in order for the tests to perform. However, often in city planning, we want to change an area for the better or for a desired outcome. Therefore, the study of outliers, over performers and under performers is necessary. We can use statistics to identify how trends work, or how stations normally work but, then look into outliers to see how stations might be altered. For example, if 7th Street and Union Station were excluded from this study we would have very little information on the relationship between transfers available and ridership, or that different development strategies could both create strong ridership in Los Angeles. From the research methods and conclusions presented in this thesis it is clear there should be a dialogue between quantitative and qualitative methods in transport planning for transit-oriented development success. Hospitable environments tor pedestrians, bicyclists and riders of passenger rail reduce auto trips, pollution and increase public health through active and sustainable modes.

Public health and pollution are major concerns today with these undesirable effects connected to auto use (Boarnet and Crane, 2001). Passenger rail and transit-oriented development offers a promising way of building cities that not only reduces undesirable outcomes but, can coincide with good neighbourhoods and a high quality of life (Boarnet and Crane, 2001). However, we still have a lack of knowledge in how the built environment affects behaviour change and these topics should be the cornerstone of future urban planning research (Boarnet and Crane, 2001).

This thesis was begun to identify the place impact on passenger rail ridership to argue for more investment in the public realm via transport funds. Along the way, an increased interest in public health and its relationship to passenger rail use was developed. Understanding how lower auto emissions from train use as well as associated active travel became an avenue of this research and is of increasing interest to transport agencies.

Furthermore, as places are increasingly both concentrating and dispersing transport connections must do more to both connect people and mitigate environmental health costs. Commonalities and contrasts have been shown from the five case study cities presented in this thesis. The entrepreneurial spirit of transport agencies in Hong Kong, London, Los Angeles and Medellin describe the current world where economics rules but also show an optimism of public agencies subverting the systems for public gain. In another show of optimism, examples of good urbanism can be seen across the five cities, especially in Berlin. Los Angeles, possibly the city of these five that needs the most urbanist attention towards station areas, revealed an expansive diversity of station architecture strategy that symbolizes the diversity of the city itself. In methodological process, this thesis analyses these issues from different quantitative and qualitative perspectives in order to judge these cities more holistically. This is important to reveal parts of these cases that are often missed in typical urban planning discourses that may stereotype cities.

While some of the highest ridership stations studied through this thesis show an inverse relationship with place quality many more stations show that trade offs between place quality and high transport use are not necessarily required. It has been shown that in many ways, high place quality does increase public transport ridership.

Finally, some things are more important than the movement of people and goods, namely, the quality of our experience once we get there.

13 Appendix A

Table 30. list of interview participants by date with title and organization.

Senior City Planner Department of City Planning City of Los Angeles	April 18, 2012
Principal Transportation Engineer Los Angeles Department of Transportation	April 18, 2012
Head of Urban Design Studio Department of City Planning City of Los Angeles	April 18, 2012
Director of Environmental Compliance Los Angeles County Metropolitan Transportation Authority	April 20, 2012
Director and Professor-in-Residence California Center for Sustainable Communities University of California Los Angeles	June 25, 2012
Associate Professor Civil, Environmental, and Sustainable Engineering School of Sustainable Engineering and the Built Environment Arizona State University	July 5, 2012
Principal Moule and Polyzoides Architects and Urbanists Adjunct Associate Professor University of Southern California School of Architecture Adjunct Associate Professor University of Southern California Sol Price School of Public Policy	August 13, 2013
Joint Development Program Manager Los Angeles County Metropolitan Transportation Authority	August, 13 2013
Chief of Real Property Management and Development Los Angeles County Metropolitan Transportation Authority	August 13, 2013
Design Partner Johnson Fain Architecture and Planning	August 15, 2013
Principal Johnson Fain Architecture and Planning	August 15, 2013
Director of Real Property and Development Los Angeles County Metropolitan Transportation Authority	August 15, 2013
Policy Director Urban and Environmental Institute Occidental College	August 16, 2013

INTERVIEW CONSENT AND INFORMATION SHEET

This form is to give Brian Garcia, and only Brian Garcia, permission to use information given during this interview in his personal doctoral work. The information will be used anonymously with names changed, or general titles used in final use. Consent may be given verbally.

This research looks predominantly at the built environment and its contextual relationship to public transport and successful ridership numbers. The research investigates neighbourhood land use as enabling or disabling access to light rail and bus rapid transit for optimal ridership. This study supposes that ridership numbers are key to social, economic and environmental benefits.

The interviews are used for information gathering and to develop a holistic view of the relationship between land use change and public transport.

I ______________________________________Date _________ consent to having the information during my interview used for Brian Garcia's doctoral thesis research.

Figure 94. Introduction and consent form.

SEMI-STRUCTURED INTERVIEW QUESTIONS SAMPLE

Part 1

What are the current land-use or transit-oriented development projects?

What land-use or transit-oriented development projects are you currently working on?

What are the aims of these projects?

What is the composition of these projects concerning land use and transport connections?

How is sustainability involved in these projects?

How does walkability factor into these projects?

Part 2

What are the processes for development of projects?

How have these projects come about?

What is the ownership make up of these projects?

How do you make these projects attractive to developers?

Part 3

Do you have any comments on this process?

What passenger rail ridership data is available?

What economic data is available for these projects?

What are the important future goals or priorities?

What are the main challenges going forward?

What recommendations do you have for land use and transit-oriented development?

Figure 95. List of interview questions for conversation starting and touching on key areas of inquiry.

Table 31. Planning documents related to sustainable redevelopment agendas analysed.

PLANNING DOCUMENT OR REPORT	AGENCY
LA Metro 30/10 Initiative Report, 2010	Los Angeles County Metropolitan Transportation Authority
Bicycle-Rail Trip Analysis and Greenhouse Gas Emissions Reduction Focused Study	Los Angeles County Metropolitan Transportation Authority
LA Metro 2015 Energy and Resource Report: Moving Towards Sustainability	Los Angeles County Metropolitan Transportation Authority
Quantifying The Influence of Transit on Land Use Patterns in LA County, 2012	Los Angeles County Metropolitan Transportation Authority
LA County Bicycle Master Plan, 2012	County Of Los Angeles
LA City Bicycle Plan, 2010	City Of Los Angeles
LA County General Plan, 2015	County Of Los Angeles
LA City Mobility Plan 2035, 2014	City Of Los Angeles
Mayor's LA Sustainability Plan, 2015	Mayor Of Los Angeles
LA Metro Long Range Transportation Plan, 2009	Los Angeles County Metropolitan Transportation Authority
LA Metro Short Range Plan, 2014	Los Angeles County Metropolitan Transportation Authority
LA Metro Bicycle Transportation Strategic Plan, 2006	Los Angeles County Metropolitan Transportation Authority
LA Metro Climate Action Plan, 2012	Los Angeles County Metropolitan Transportation Authority
LA Metro Energy Conservation and Management Plan, 2011	Los Angeles County Metropolitan Transportation Authority
Greenhouse Gas Emissions Cost Effectiveness Study, 2010	Los Angeles County Metropolitan Transportation Authority
LA Metro Water Action Plan, 2010	Los Angeles County Metropolitan Transportation Authority
Sustainable Rail Plan, 2013	Los Angeles County Metropolitan Transportation Authority
Metro Vision 2028 Strategic Plan	Los Angeles County Metropolitan Transportation Authority

14 Appendix B

Place and Public Transport Survey examining passenger rail station areas

Name ______________________ Date ______________________

Pedestrian Access and Travel

	Yes	No
Sidewalks are paths are smooth, continuous and well connected to other paths?		
Easy for older people, disabled, children, and unskilled to walk?		
Intersections are easy to cross?		
Limited grade changes or hills?		
Paths are direct and there are no barriers?		
Ground surface quality is good and/or smooth?		
Crosswalks are well timed for foot traffic?		

Environment and Comfort

	Yes	No
Visible public space?		
Plantings and trees?		
There is adequate shade?		
Good air quality and ventilation?		
Open/Green space is a strip or merely decorative?		
There is adequate sunlight?		
Places of shelter?		
Visible access to water?		
Grass is available?		
Environment is too loud?		
Air quality bad from auto exhaust etc.?		

Social Aspects

	Yes	No
People on the street?		
Undesirable people present?		
Feels safe?		

Surroundings and Land Use

	Yes	No
Food and snacks are nearby the station?		
Street level retail?		
Well lit surroundings?		
Pleasant waiting space?		
Interesting urban realm?		
Office space nearby?		
Significant residential?		

Interaction of Modes

bikes, trains, autos, buses, walking

	Yes	No
Modes interact and cooperate well?		
Connecting mode stops are visible?		
Transfering seems safe?		
Connecting stops are convenient?		

Built Environment

	Yes	No
Non Metro seating?		
Public phones?		
Roads are well proportioned to sidewalks?		
Adequte Signage?		
Clear view of surroundings?		
Blank walls or gloomy isolated environment?		
Clean and well maintained?		
Human scale or lack of mega structures?		

Overall Ranking

1) I Want to stay here 2) It is Pretty Good 3) Usefull 4) Difficult to Use 5) Depressing

Other Comments and Analysis:

Figure 96. Passenger rail station area place and urban design site survey checklist used to document and analyse stations and station areas.

Table 32. List of dates and daily average temperatures when station areas were surveyed (Time and Date AS, 2018). Not all stations were able to be matched with ridership or used in the analysis.

Berlin							
Station	**City**	**Date**	**Year**	**Temperate Low**	**Temperature High**	**Daily Average**	**Day of Week**
Zoologischer	Berlin	22-Feb	2014	1	10	5.5	Saturday
Alexanderplatz	Berlin	22-Feb	2014	1	10	5.5	Saturday
Oranienburger	Berlin	22-Feb	2014	1	10	5.5	Saturday
Wedding	Berlin	22-Feb	2014	1	10	5.5	Saturday
Friedrichstraße	Berlin	22-Feb	2014	1	10	5.5	Saturday
Rosenthaler Platz	Berlin	22-Feb	2014	1	10	5.5	Saturday
Schwartzkopffstraße	Berlin	22-Feb	2014	1	10	5.5	Saturday
Naturkunde Museum	Berlin	22-Feb	2014	1	10	5.5	Saturday
Bernauer Straße	Berlin	22-Feb	2014	1	10	5.5	Saturday
Nordbahnhof	Berlin	22-Feb	2014	1	10	5.5	Saturday
Reinickendorfer Straße	Berlin	22-Feb	2014	1	10	5.5	Saturday
Weinmeister Straße	Berlin	23-Feb	2014	2	10	6	Sunday
Hackescher Markt	Berlin	23-Feb	2014	2	10	6	Sunday
Franzosische Straße	Berlin	23-Feb	2014	2	10	6	Sunday
Rosa Luxemburg Platz	Berlin	23-Feb	2014	2	10	6	Sunday
Senefelderplatz	Berlin	23-Feb	2014	2	10	6	Sunday
Bundestag	Berlin	24-Feb	2014	1	13	7	Monday
Brandenburger Tor	Berlin	25-Feb	2014	2	13	7.5	Tuesday
Kottbusser Tor	Berlin	26-Feb	2014	3	14	8.5	Wednesday
Potsdamer Platz	Berlin	26-Feb	2014	3	14	8.5	Wednesday
Kurfurstendamm	Berlin	26-Feb	2014	3	14	8.5	Wednesday
Wittenberg	Berlin	26-Feb	2014	3	14	8.5	Wednesday
Hong Kong							
Station	**City**	**Date**	**Year**	**Temperate Low**	**Temperature High**	**Daily Average**	**Day of Week**
Admiralty	Hong Kong	14-Apr	2014	24	27	25.5	Monday
Tsim Sha Tsui	Hong Kong	15-Apr	2014	22	26	24	Tuesday
Causeway Bay	Hong Kong	15-Apr	2014	22	26	24	Tuesday
Kowloon Bay	Hong Kong	17-Apr	2014	23	30	26.5	Thursday
Chai Wan	Hong Kong	17-Apr	2014	23	30	26.5	Thursday
Tseung Kwan O	Hong Kong	17-Apr	2014	23	30	26.5	Thursday
North Point	Hong Kong	17-Apr	2014	23	30	26.5	Thursday
Central	Hong Kong	17-Apr	2014	23	30	26.5	Thursday
Hong Kong Airport Express	Hong Kong	17-Apr	2014	23	30	26.5	Thursday
Sheung Wan	Hong Kong	17-Apr	2014	23	30	26.5	Thursday

University	Hong Kong	19-Apr	2014	23	29	26	Saturday
Mong Kok	Hong Kong	19-Apr	2014	23	29	26	Saturday
Jordan	Hong Kong	20-Apr	2014	25	29	27	Sunday
Tai Koo	Hong Kong	22-Apr	2014	24	29	26.5	Tuesday
Quarry Bay	Hong Kong	22-Apr	2014	24	29	26.5	Tuesday
London							
Station	**City**	**Date**	**Year**	**Temperate Low**	**Temperature High**	**Daily Average**	**Day of Week**
Shepherd's Bush	London	18-Mar	2014	7	14	10.5	Tuesday
New Cross Gate	London	18-Mar	2014	7	14	10.5	Tuesday
Euston	London	18-Mar	2014	7	14	10.5	Tuesday
Willesden Junction	London	18-Mar	2014	7	14	10.5	Tuesday
Clapham Junction	London	18-Mar	2014	7	14	10.5	Tuesday
Canada Water	London	18-Mar	2014	7	14	10.5	Tuesday
Stratford	London	18-Mar	2014	7	14	10.5	Tuesday
Dalston Kingsland	London	18-Mar	2014	7	14	10.5	Tuesday
Highbury and Islington	London	18-Mar	2014	7	14	10.5	Tuesday
Shadwell	London	18-Mar	2014	7	14	10.5	Tuesday
Whitechapel	London	19-Mar	2014	7	16	11.5	Wednesday
Shoreditch High Street	London	19-Mar	2014	7	16	11.5	Wednesday
Heron Quays	London	25-Mar	2014	3	9	6	Tuesday
Cutty Stark	London	25-Mar	2014	3	9	6	Tuesday
Canary Wharf	London	25-Mar	2014	3	9	6	Tuesday
Greenwich	London	25-Mar	2014	3	9	6	Tuesday
Bank	London	25-Mar	2014	3	9	6	Tuesday
Lewisham	London	25-Mar	2014	3	9	6	Tuesday
Limestone	London	26-Mar	2014	2	8	5	Wednesday
Canning Town	London	26-Mar	2014	2	8	5	Wednesday
Los Angeles							
Station	**City**	**Date**	**Year**	**Temperate Low**	**Temperature High**	**Daily Average**	**Day of Week**
Wilshire and Vermont	Los Angeles	9-Aug	2013	16	24	20	Friday
Union Station	Los Angeles	9-Aug	2013	16	24	20	Friday
7th Street	Los Angeles	9-Aug	2013	16	24	20	Friday
Hollywood and Highland	Los Angeles	9-Aug	2013	16	24	20	Friday
Westlake MacArthur Park	Los Angeles	9-Aug	2013	16	24	20	Friday
Little Tokyo	Los Angeles	12-Aug	2013	17	26	21.5	Monday
Exposition and Western	Los Angeles	12-Aug	2013	17	26	21.5	Monday
Exposition and Vermont	Los Angeles	12-Aug	2013	17	26	21.5	Monday
Culver City	Los Angeles	12-Aug	2013	17	26	21.5	Monday
Aviation Los Angeles Airport	Los Angeles	10-Sep	2013	16	24	20	Tuesday
Fillmore	Los Angeles	10-Sep	2013	16	24	20	Tuesday

Del Mar	Los Angeles	10-Sep	2013	16	24	20	Tuesday
Pico	Los Angeles	10-Sep	2013	16	24	20	Tuesday
Hollywood and Vine	Los Angeles	10-Sep	2013	16	24	20	Tuesday
Florence	Los Angeles	10-Sep	2013	16	24	20	Tuesday
1st Street Long Beach	Los Angeles	10-Sep	2013	16	24	20	Tuesday
Compton	Los Angeles	10-Sep	2013	16	24	20	Tuesday
Highland Park	Los Angeles	12-Sep	2013	16	27	21.5	Thursday
Universal City	Los Angeles	12-Sep	2013	16	27	21.5	Thursday
Vermont Green Line	Los Angeles	12-Sep	2013	16	27	21.5	Thursday
Willow	Los Angeles	12-Sep	2013	16	27	21.5	Thursday
Pershing Square	Los Angeles	12-Sep	2013	16	27	21.5	Thursday
Memorial Park	Los Angeles	12-Sep	2013	16	27	21.5	Thursday
Norwalk	Los Angeles	12-Sep	2013	16	27	21.5	Thursday
Crenshaw	Los Angeles	12-Sep	2013	16	27	21.5	Thursday
North Hollywood	Los Angeles	12-Sep	2013	16	27	21.5	Thursday
Willowbrook	Los Angeles	12-Sep	2013	16	27	21.5	Thursday
Wilshire and Western	Los Angeles	12-Sep	2013	16	27	21.5	Thursday
Chatsworth	Los Angeles	12-Sep	2013	16	27	21.5	Thursday
Sierra Madre Villa	Los Angeles	12-Sep	2013	16	27	21.5	Thursday
Civic Center	Los Angeles	13-Sep	2013	17	28	22.5	Friday
Harbor Freeway	Los Angeles	13-Sep	2013	17	28	22.5	Friday
Medellin							
Station	**City**	**Date**	**Year**	**Temperate Low**	**Temperature High**	**Daily Average**	**Day of Week**
Poblado	Medellin	4-Apr	2014	14	23	18.5	Friday
Estadio	Medellin	4-Apr	2014	14	23	18.5	Friday
Prado	Medellin	4-Apr	2014	14	23	18.5	Friday
Envigado	Medellin	6-Apr	2014	15	23	19	Sunday
Industriales	Medellin	6-Apr	2014	15	23	19	Sunday
Sabaneta	Medellin	6-Apr	2014	15	23	19	Sunday
La Estrella	Medellin	6-Apr	2014	15	23	19	Sunday
Itagui	Medellin	6-Apr	2014	15	23	19	Sunday
San Antonio	Medellin	7-Apr	2014	15	24	19.5	Monday
Suramerica	Medellin	7-Apr	2014	15	24	19.5	Monday
Santa Lucia	Medellin	7-Apr	2014	15	24	19.5	Monday
San Javier	Medellin	7-Apr	2014	15	24	19.5	Monday
Floresta	Medellin	7-Apr	2014	15	24	19.5	Monday
Cisneros	Medellin	7-Apr	2014	15	24	19.5	Monday
Hospital	Medellin	8-Apr	2014	13	23	18	Tuesday
Parque Berra	Medellin	8-Apr	2014	13	23	18	Tuesday
Alpujarra	Medellin	8-Apr	2014	13	23	18	Tuesday

Ayura	Medellin	8-Apr	2014	13	23	18	Tuesday
Expositiones	Medellin	8-Apr	2014	13	23	18	Tuesday
Aguacatala	Medellin	8-Apr	2014	13	23	18	Tuesday
Tricentenario	Medellin	9-Apr	2014	12	21	16.5	Wednesday
Acevedo	Medellin	9-Apr	2014	12	21	16.5	Wednesday
Madera	Medellin	9-Apr	2014	12	21	16.5	Wednesday
Bello	Medellin	9-Apr	2014	12	21	16.5	Wednesday
Niquia	Medellin	9-Apr	2014	12	21	16.5	Wednesday
Universidad	Medellin	9-Apr	2014	12	21	16.5	Wednesday
Caribe	Medellin	9-Apr	2014	12	21	16.5	Wednesday

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